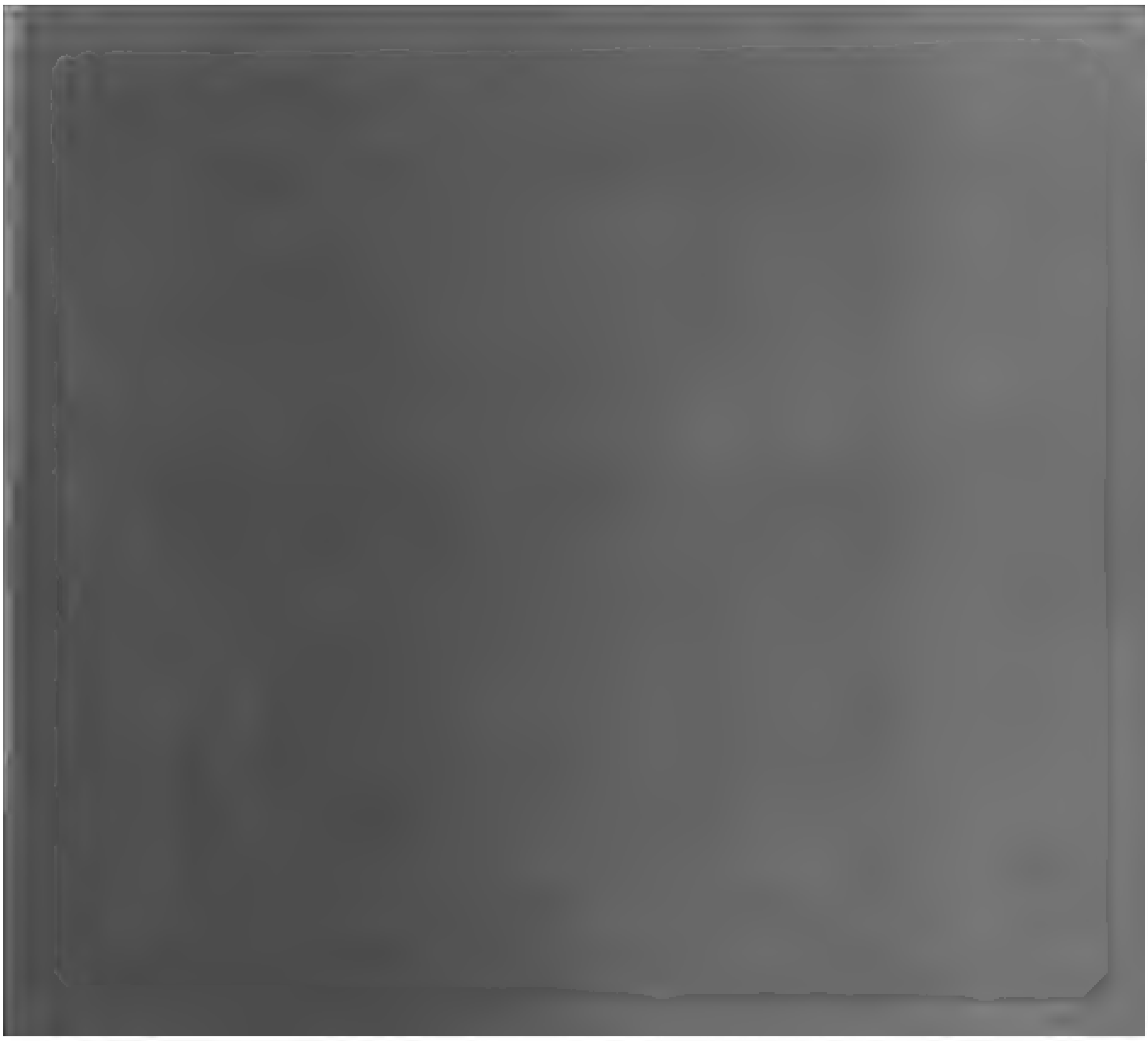


[UNDER REVISION.]

Science and Art Department
of the Committee of Council on Education.

CATALOGUE

OF THE

SPECIAL LOAN COLLECTION OF SCIENTIFIC APPARATUS

AT THE

SOUTH KENSINGTON MUSEUM.

MDCCCLXXVI.

SECOND EDITION.

LONDON:
PRINTED BY GEORGE E. EYRE AND WILLIAM SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.
FOR HER MAJESTY'S STATIONERY OFFICE.

1876.

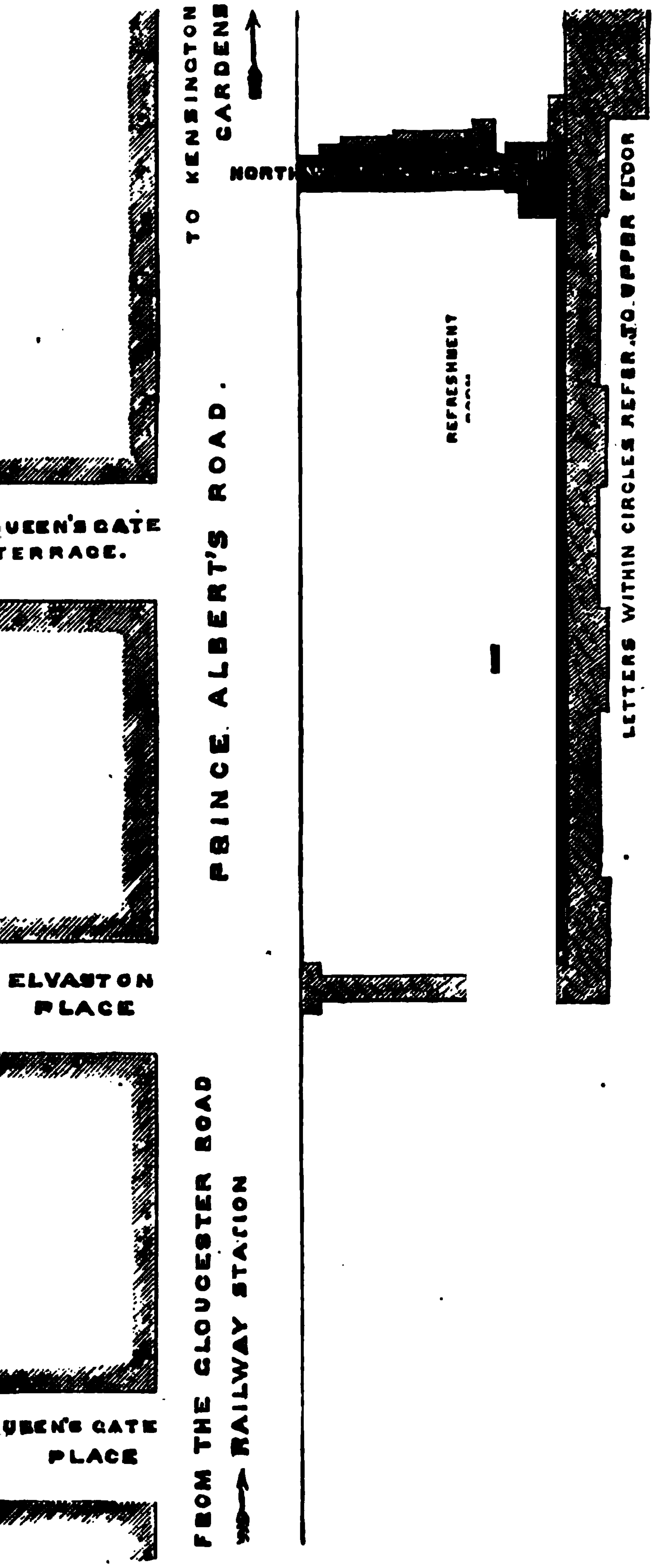
T.A.M.

SOUTH K

LOAN COLLECTION

PLAN OF GALLERIES LENT BY

Ro



REFERE

GR

A EDUCATION

B.C. APPLIED

D NAVAL ARC

E LIGHT-HOU

F MAGNETISM

G ARITHMETI

H.K. MEASUREMI

L. ASTRONOM

U

(M) GEOGRAPHY

(N) BIOLOGY.

(O) CONFEREN

(P) CHEMISTRY

(Q) LIGHT, HEAT,

INTRODUCTION.

By Minute dated 22nd January 1875, the Lords of the Committee of Council on Education approved of a proposal to form a Loan Collection of Scientific Apparatus, which was to include not only apparatus for teaching and for investigation, but also such as possessed historic interest on account of the persons by whom, or the researches in which, it had been employed. Their Lordships then invited some of the leading men of science of the country—the Presidents of the learned Societies and others—to act on a Committee to consider the matter, and aid them with their advice. This Committee, to whose exertions the formation of the collection is so largely due, consisted of—

The Right Hon. the Lord Chancellor.
Professor F. A. Abel, F.R.S., President of the Chemical Society.
The Right Hon. Lord Aberdare, President of the Horticultural Society.
Capt. W. de W. Abney, R.E., F.R.S.
Professor H. W. Acland, M.D., F.R.S., President of the Medical Council of the United Kingdom.
Professor J. C. Adams, M.A., F.R.S.
Professor W. G. Adams, M.A., F.R.S.
Sir G. B. Airy, K.C.B., D.C.L., F.R.S., the Astronomer Royal.
Dr. G. J. Allman, F.R.S., President of the Linnæan Society.
Mr. J. Anderson, LL.D., C.E.
Mr. D. T. Ansted, M.A., F.R.S.
Professor E. Atkinson, Ph.D.
Professor R. Stawell Ball, LL.D., F.R.S.
Professor W. F. Barrett.
Rev. A. Barry, D.D.
Mr. W. B. Baskcomb.
Mr. H. Bauerman.
Mr. G. Bentham, F.R.S.
Mr. Hugh Birley, M.P.
Professor Bloxam.
Major Bolton.
Professor F. A. Bradley.
Mr. F. J. Bramwell, F.R.S.
Mr. T. Brassey, M.P.
Mr. H. W. Bristow, F.R.S.
Mr. C. Brooke, M.A., F.R.S.
Mr. G. Busk, F.R.S.
Major-General Cameron, C.B., F.R.S.
Dr. W. B. Carpenter, C.B., F.R.S.
Mr. C. O. F. Cator.
Mr. W. Chappell.
Mr. H. W. Chisholm, Warden of the Standards.
Lord Alfred Churchill, Chairman of Council of Society of Arts.
Mr. G. T. Clark.
Mr. Latimer Clark.
Professor R. Bellamy Clifton, M.A., F.R.S.
Sir Henry Cole, K.C.B.
Vice-Admiral Sir R. Collinson, K.C.B., Deputy Master of the Trinity House.
Dr. Debus, F.R.S.
Mr. Warren De La Rue, D.C.L., F.R.S.
Mr. G. Dixon, M.P.
Professor P. M. Duncan, M.B., F.R.S., President of the Geological Society.
Professor W. T. Thiselton Dyer, M.A., B.Sc.
Major-General F. Eardley-Wilmot, R.A., F.R.S.

Mr. E. S. Eaton, President of the Meteorological Society.
Sir P. De M. G. Egerton, Bart., M.P., F.R.S.
Mr. R. Etheridge, F.R.S.
Capt. Evans, R.N., C.B., F.R.S., Hydrographer of the Navy.
Mr. J. Evans, F.R.S.
Professor W. H. Flower, F.R.S.
Mr. D. Forbes, F.R.S.
Professor G. Carey Foster, B.A., F.R.S., President of the Physical Society.
Professor Michael Foster, M.D., F.R.S.
Colonel Lane Fox, F.R.S., President of the Anthropological Institute.
Professor Frankland, Ph.D., D.C.L., F.R.S.
Mr. A. H. Garrod, M.A., F.R.S.
Dr. Gilbert, F.R.S.
Dr. J. H. Gladstone, F.R.S.
Mr. D. Glasgow.
Professor Goodeve, M.A.
Mr. A. C. L. G. Günther, M.A., M.D., F.R.S.
Professor Guthrie, Ph.D., F.R.S.
Mr. J. Baillie-Hamilton.
The Right Hon. Lord Hampton, G.C.B., F.R.S., President of the Institute of Naval Architects.
Mr. T. E. Harrison.
Sir J. Hawkshaw, F.R.S.
Mr. T. Hawksley, President of the Institute of Mechanical Engineers.
The Hon. Alan Herbert.
Mr. J. Hick, M.P.
Dr. J. D. Hooker, C.B., President of the Royal Society.
Mr. J. Hopkinson, B.A., D.Sc.
Mr. W. Huggins, D.C.L., F.R.S., President of the Royal Astronomical Society.
Professor W. Hughes.
Professor T. H. Huxley, LL.D., Sec. R.S.
Lieut.-General Sir H. James, R.E., F.R.S.
Rev. J. H. Jellett, B.D.
Professor E. Ray Lankester, M.A., F.R.S.
Lord Lindsay, M.P., F.R.S.
Mr. J. Norman Lockyer, F.R.S.
Rev. R. Main, M.A., F.R.S.
Dr. R. J. Mann.
Mr. N. Story-Maskelyne, M.A., F.R.S.
Professor J. Clerk Maxwell, M.A., F.R.S.
Mr. C. W. Merrifield, F.R.S.
Professor Miller, M.A., LL.D., F.R.S.
Professor Morris.
Mr. A. J. Mundella, M.P.
Professor Odling, M.A., F.R.S.
Mr. W. K. Parker, F.R.S.
Dr. Percy, F.R.S.
Mr. J. A. Phillips.
The Right Hon. Lyon Playfair, C.B., M.P., F.R.S.
Dr. Pole, F.R.S.
Professor Prestwich, F.R.S.
Professor A. C. Ramsay, LL.D., F.R.S.
Major-General Sir H. C. Rawlinson, K.C.B., F.R.S., President of the Royal Geographical Society.
The Right Hon. Lord Rayleigh, F.R.S.
Professor A. W. Reinold, M.A.
Professor Roscoe, Ph.D., F.R.S.
The Right Hon. the Earl of Rosse, D.C.L., F.R.S.
Mr. G. W. Royston-Pigott, M.A., M.D., F.R.S.
Mr. J. Scott Russell, F.R.S.
Dr. W. J. Russell, F.R.S.
Professor W. Rutherford, M.D., F.R.S.
Mr. B. Samuelson, M.P.
Professor J. S. Burdon Sanderson, M.D., F.R.S.
Mr. T. Savage, M.A.
Mr. R. H. Scott, M.A., F.R.S.
Major Seddon, R.E.
Professor Shelley.
Sir J. P. Kay-Shuttleworth, Bart.
Mr. C. W. Siemens, D.C.L., F.R.S.
Professor H. J. S. Smith, M.A., F.R.S.
Mr. W. Warington Smyth, M.A., F.R.S.
Mr. H. C. Sorby, F.R.S., President of the Royal Microscopical Society.
Mr. W. Spottiswoode, M.A., LL.D., Treasurer of the Royal Society.
Mr. G. R. Stephenson, President of the Institution of Civil Engineers.
Professor Balfour Stewart, LL.D., F.R.S.
Dr. W. H. Stone.
Major-General Strachey, C.S.I., F.R.S.

Strange, F.R.S. (since

G. Tait, M.A.
M.P.
wisden, M.A.
ndall, LL.D., F.R.S.
. C. Unwin, B.Sc.
Walker, F.R.S., Presi-
Society of Telegraphic
.

Mr. F. H. Wenham.
Sir C. Wheatstone, F.R.S. (since deceased).
Sir J. Whitworth, Bart., F.R.S.
Professor A. W. Williamson, Ph.D., F.R.S.
Mr. Bennet Woodcroft, F.R.S.
Dr. J. Woolley, F.R.S.
Colonel H. Stuart Wortley.

st meeting of this Committee was held on the 13th 1875; the number of those who were present he interest already felt in the subject. The Lord of the Council, the Duke of Richmond, and the ident, Viscount Sandon, in explaining the objects llection, took occasion to refer to the recommenf the Royal Commission on Scientific Instruction, rd to the creation of a Science Museum.

Lordships stated their conviction that the develophe Educational, and certain other, Departments of Kensington Museum, and their enlargement into m somewhat of the nature of the *Conservatoire et Métiers* in Paris, and other similar institutions Continent, would tend to the advancement of nd be of great service to the industrial progress ountry. While expressing their hope that the lection might forward this desirable object, their guarded themselves against committing Her Maovernment, which had not yet fully considered ct, to any definite scheme.

e motion of the President of the Royal Society, er, it was unanimously resolved by the meeting exhibition such as that proposed would be most e and valuable.

estion of the limits of the collection were disnd Sub-Committees were appointed to consider the ns it might be desirable to place on the term ic apparatus " in the respective sections, while n mind the space disposable for the exhibition in um. As a provisional arrangement five Sub-Comf sections were appointed, to whom it was left to uch modifications in classification as might be found

The sections were—

1. Mechanics (including pure and applied mathematics).
2. Physics.
3. Chemistry (including metallurgy).
4. Geology, Mineralogy, and Geography.
5. Biology.

The Committees for the several sections are given at page xxi.

The question of classification, having been carefully considered at numerous meetings of these Sub-Committees, was brought before the General Committee on the 12th May, and the several schemes were referred to a special Sub-Committee, formed of three members from each sectional Sub-Committee. It was also decided to postpone the Exhibition, which it was originally intended to open in June 1875, to March 1876. The large number of objects sent from abroad, and the late period of their arrival, have necessitated a further postponement of the opening to May 1876.

The Sub-Committee appointed to revise and report on the classification of the Collection after three meetings, under the chairmanship of the President of the Royal Society, submitted a scheme of classification to the General Committee on June 22nd. After having been carefully considered, it was, with some slight alterations, approved, and is given at page xv. This programme was immediately issued, and the classification into sections is that adopted for the catalogue and exhibition, though the nature of the Galleries has necessitated some alteration in the order of the sections.

It had been the intention from the first to give the Loan Collection an international character, so as to afford men of science and those interested in education an opportunity of seeing what was being done by other countries than their own in the production of apparatus, both for research and for instruction—an opportunity which it was hoped would be of advantage also to the makers of instruments. As soon, therefore, as the programme had been definitely settled, steps were taken to interest foreign countries in the Exhibition; and it was determined to obtain the co-operation of men of science on the Continent, who, while acting as members of

the General Committee, should form special Sub-Committees charged with the due representation of the science of their respective countries.

It was necessary to take special precautions to prevent misunderstanding as to the character of the Collection. The mention of internationality at once suggested the idea of an International Exhibition similar in its character and arrangements to the numerous Industrial Exhibitions which have been held in various countries. A wrong impression of this kind would have entailed serious inconvenience.

In International Exhibitions a certain amount of space is allotted to each country. These spaces are then divided by the Commissioners of each country among its exhibitors, who display their objects—subject to certain general rules of classification—as they consider most advantageous, retaining the custody of their own property. The expenses of transport, arrangement, &c., are borne by the countries who exhibit. And the Exhibitions appeal naturally, more or less exclusively, to the industrial or trade-producing interests of those countries.

This was not the idea of the proposed Loan Collection at South Kensington. For that Collection it was desired to obtain not only apparatus and objects from manufacturers, but also objects of historic interest from museums and private cabinets, where they are treasured as sacred relics, as well as apparatus in present use in the laboratories of professors. The transport of all objects was undertaken by the English Government, and they were to be handed over absolutely to the custody of the Science and Art Department for exhibition; the arrangement being not by countries but strictly according to the general classification.

So soon as the object and scope of the Collection were thoroughly understood, the Committee of Council on Education met with the most gratifying responses to their invitations, which were communicated officially through the Foreign Office. Her Majesty's Ministers at Paris, Berlin, St. Petersburgh, Vienna, Florence, Brussels, the Hague, Stockholm, Madrid, Berne, and Washington, have personally interested themselves in the matter. And the Foreign Governments have afforded every facility and encouragement in forwarding this strictly international undertaking.

The subjoined list of the foreign members of the Committee speaks for itself by the eminence and E reputation of its members.

BELGIUM.

M. Stas, Membre de l'Académie Royale (President).

M. le Général Brialmont, Président de l'Académie Royale et Inspecteur Général du Génie.

M. Dewalque, Membre de l'Académie Royale, Professeur de Géologie et de Minéralogie à l'Université de Liége.

M. Maus, Membre de l'Académie, Inspecteur Général des Ponts et Chaussées.

M. Plateau; Membre de l Royale, F.R.S.

M. Schwann, Membre de l Royale, Professeur à l'Ur Liége.

M. Van Beneden, Membre démie et Professeur à l' de Louvain, F.R.S.

M. le Général Liagre, Secr pétuel de l'Académie Commandant et Dire Études de l'École Milita tary).

FRANCE.

M. le Général Arthur Jules Morin, Membre de l'Académie des Sciences, Directeur du Conservatoire des Arts et Métiers (President).

M. Alexre. Edmond Becquerel, Membre de l'Académie des Sciences, Professeur au Conservatoire des Arts et Métiers, F.R.S.

M. Henri Marie Bouley, Membre de l'Académie des Sciences, Inspecteur Général des Écoles Vétérinaires.

M. Gabriel Auguste Daubrée, Membre de l'Académie des Sciences, Directeur de l'École des Mines.

M. Jean Louis Armand de Quatrefages de Bréau, Membre de l'Académie des Sciences, Professeur au Museum d'Histoire Naturelle.

M. Jean Baptiste Dumas, Secrétaire perpétuel de l'Académie des Sciences, F.R.S.

M. Hervé Auguste Etien Faye, Membre de l'Aca Sciences, Président du l Longitudes.

M. Edmond Frémy, M l'Académie des Science seur au Museum d'Hist relle.

M. Jules Célestin Jamin, l'Académie des Science seur à l'École Polytechn

M. Lenglet, Consul Général à Londres.

M. Urbain Jean Joseph L Membre de l'Acad Sciences, Directeur de toire, F.R.S.

M. Eugène Melchior Peli bre de l'Académie des Directeur des Essais à la

M. Henri Edouard Tresc de l'Académie des Scien Directeur du Conserv Arts et Métiers (Secreta

GERMANY.

I.—Berlin Committee.

Dr. A. W. Hofmann, Professor of Chemistry, F.R.S. (President).

Dr. Beyrich, Professor of Geology.

Dr. du Bois-Reymond, Professor of Physiology.

Dr. Dove, Professor of Physics, F.R.S.

Dr. Förster, Director of t vatory.

Dr. Hagen, President of th Works.

T. G. Halske, Telegrap neer.

:hecorne, Director of the
of Mines.
iholtz, Professor of Physics,

ipert, Professor of Geo-
'.
Kirchhoff, Professor of Phy-
.R.S.
ıecker, Professor of Mathe-
.
). Martius, Chemist.
rozowicz, General.

Dr. Neumayer, Hydrographer of the Imperial Admiralty.
Dr. Reuleaux, Director of the Polytechnic Academy.
Dr. Schellbach, Professor of Mathematics.
Dr. Werner Siemens, Telegraphic Engineer.
Dr. Virchow, Professor of Pathology.
Dr. C. H. Vogel, Astronomer.
Dr. Websky, Professor of Mineralogy.

-COMMITTEE REPRESENTING OTHER CITIES AND TOWNS OF GERMANY.

ı Babo, Professor of Che-
', Freiburg.
etz, Professor of Physics,
h.
, Professor of Physics, Gies-

asius, Professor of Physics,
F.R.S.
cellency Dr. Von Dechen,
or of the Mining Depart-
Bonn.
ı Fehling, Professor of Che-
', Stuttgart.
n Feilitzsch, Professor of
s, Greifswald.
ebe, Professor of Chemistry,
sberg.
Groddeck, Director of the
l of Mines, Klausthal.
ren, Professor of Chemistry,
ver.
orf, Professor of Chemistry,
ter.
rsten, Professor of Physics,

rsten, Professor of Physics,
ck.
ıpp, Professor of Chemistry,
ıschweig.
blauch, Professor of Physics,
.
liker, Professor of Physiology,
tburg, F.R.S.
ındt, Professor of Physics,
ıburg.
mhardt, Director of the Poly-
nic School, Hanover.
öhl, Cassel.

Dr. Poleck, Professor of Chemistry, Breslau.
Dr. Preyer, Professor of Physiology, Jena.
Dr. Von Quintus-Icilius, Professor of Physics, Hanover.
Dr. Reusch, Professor of Physics, Tübingen.
Dr. Romberg, Professor in the Nautical School, Bremen.
Dr. Rosenthal, Professor of Physiology, Erlangen.
Dr. Rümker, Director of the Observatory, Hamburg.
Dr. Serlo, Director of the Mining Department, Breslau.
Dr. C. Von Siemens, Professor in the Agricultural Academy, Hohenheim.
His Excellency Dr. Von Steinbeis, President, Stuttgart.
Dr. W. Weber, Professor of Physics, Göttingen, F.R.S.
Dr. Wiedemann, Professor of Physical Chemistry, Leipzig.
Dr. Winkler, Professor of Metallurgy, Freiberg.
Dr. Wöhler, Professor of Chemistry, Göttingen, F.R.S.
Dr. Wüllner, Professor of Physics, Aachen.
Dr. Zeuner, Director of the Polytechnic School, Dresden.
Dr. Zetzsche, Director of the Polytechnic School, Chemnitz.

them, will reward them for the labours which they have ungrudgingly devoted to it.

In order to make the Collection as useful and interesting as possible, a Handbook containing introductory notices to the several sections has been prepared. For writing these notices the Lords of the Committee of Council on Education have been fortunate in securing the services of gentlemen the mention of whose names will be a sufficient indication of the character of the work. These gentlemen are—

Capt. W. de W. Abney, R.E.
Professor W. Kingdon Clifford, M.A., F.R.S.
Capt. J. E. Davis.
Professor G. Carey Foster, B.A., F.R.S.
Professor Geikie, F.R.S.
Professor Goodeve, M.A.
Professor Guthrie, F.R.S.
Professor T. H. Huxley, LL.D., Secretary of the Royal Society.
Mr. J. Norman Lockyer, F.R.S.
Professor MacLeod.
Mr. Clements Markham, C.B., F.R.S.
Mr. N. Story Maskelyne, M.A., F.R.S.
Professor J. Clerk Maxwell, M.A., F.R.S.
Mr. R. H. Scott, M.A., F.R.S.
Professor H. J. S. Smith, M.A., F.R.S.
Mr. W. Warington Smyth, M.A., F.R.S.
Mr. H. C. Sorby, F.R.S.
Mr. W. Spottiswoode, M.A., LL.D., F.R.S.
Dr. W. H. Stone.
Professor P. G. Tait, M.A.

It had been originally proposed to exhibit the Collection of Scientific Apparatus in the South Kensington Museum; but various circumstances, which could not be foreseen, having rendered it necessary to abandon this intention, Her Majesty's Commissioners for the Exhibition of 1851, most liberally placed the galleries on the western side of the Horticultural Gardens at the disposal of the Science and Art Department. Though, unfortunately, these galleries are disconnected from the Kensington Museum, they are admirably adapted to the present purpose, and afford an accommodation which could not otherwise have been obtained.

By order,

F. R. SANDFORD,
Secretary, Committee of Council on Education.

CLASSIFICATION OF THE COLLECTION.

Arithmetic.

Apparatus for teaching arithmetic.—Calculating machines.—Instruments for solving equations.—Slide rules.—Numbering and enumerating apparatus, &c.

Geometry.

Instruments used in geometrical drawing.—Methods of copying—Pantigraph, micrograph.—Peaucellier's cell and parallel motion—Machines for description of curves and specimens of the curves they describe, including geometric turning.—Instruments for giving graphic representations of phenomena.—Models to illustrate descriptive geometry.—Specimens to illustrate the process of making models according to a design.—Models to illustrate solid geometry, perspective, crystallography, &c.—Stereoscopic illustrations of solid geometry.

Measurement.

Of length.—Standard yard, metre, &c.—Comparator for standards of length (sight and touch).—Gauges, measuring wheels, steel tapes, &c.—Micrometers and verniers.—Cathetometers.

Of area.—Planimeters, &c.

Of volume.—Standard gallon, litre, &c.—Pipettes, burettes.—Meters for gas, water, &c.

Of angles.—Divided circles, theodolites, clinometers, goniometers, &c.

Of mass.—Standard pound, kilogramme, &c.—Vacuum and other balances.

Of density.—Specific gravity bottles, areometers, &c.

Of time.—Clocks and pendulums, chronometers, watches, and balance wheels.—Tuning forks for measuring small intervals of time.—Chronographs.

Of velocity.—Such as Morin's machine.—Strophometers, current meters, ships' logs, &c.

Of momentum.—Ballistic apparatus.

Of force.—Spring balances, pressure gauges, torsion balances, &c.

Of work.—Indicators, dynamometers, &c.

Kinematics, Statics, and Dynamics.

Elementary illustrations.—Position and displacement of a point, a rigid body, or a material system.—Composition and resolution of displacements.—Velocity and acceleration, their composition and

resolution.—Displacements of a connected system.—Principles of mechanism.—Rolling contact, sliding contact, belting, link connexions, shafting, universal joints, &c.—Transmission of work.—Relation between the displacement of two pieces of a machine and the forces which they transmit.—The mechanical powers.—Instruments for illustrating the laws of motion, such as pendulums, gyroscopes, dynamical tops.

Laws of fluid pressure; stability of floating bodies.

Discharge of fluids through orifices, and their motion in channels.

Hydraulic and pneumatic transmission of power.

Molecular Physics.

Instruments and apparatus employed in teaching, and in the investigations and observations connected with :—

Pressure on Matter.—Tension, Compression (piezometer) Torsion, Flexion; Relation of volume to pressure; Elasticity of liquids and gases.—Hardness (of solids and liquids), Toughness, Brittleness, Malleability, &c.

Communication of Pressure through Fluids.—Pressure of air, its consequences and applications.—Barometers, Air-pumps, Siphons, Suction-pumps, Spirators, &c.; Pressure of water, its consequences and applications,—Levels, Side pressure, &c.

Density.—Methods of measuring densities of Gases, Vapours, Liquids, Solids.

Adhesion and Cohesion.—Condensation of gases in solids, Solution of gases in liquids. Mixing of gases with gases (Diffusion, Transpiration, &c.), Absorption of liquids by solids (Capillarity, &c.). Absorption of liquids by gases (Evaporation, &c.), Mixing of liquids with liquids (Osmose, Diffusion Dialysis).—Evaporation of solids, Solution of solids, Mixture of solids with solids (Cementation, &c.).

Sound.

Instruments and apparatus employed in teaching, and in the investigations and observations connected with :—

Geometrical, Mechanical, and Optical methods of Illustrating the Laws of Wave Motion.—Progressive waves, Composition of Vibrations, Interference, Stationary waves.

Generation of Sound.—Fog-horn, &c.

Conduction of Sound.—Through solids, liquids, and gases, Stethoscopes.

Velocity of Sound.

Detection of Sound.—Sensitive flame, &c.

Reflexion and Refraction.—Ear trumpets, Acoustic lenses, &c.

Dispersion and Absorption.

al Sounds.—Pitch, Standards of Pitch, Standard Tuning &c.; Methods of measuring and comparing rates of vibra- oothed wheels, Syrens, &c.; Vibration Microscopes, &c.; s of illustrating the nature of musical intervals; Mano- lames, Mirrored Tuning Forks, &c.
cal Quality.—Illustrations of the different quality of the of various instruments, Harmonics, and overtones, Resul- es, Instruments for studying quality, Resonators, Phonau- s, &c.
cal Instruments Illustrating the above.—Methods of ex- the mode of vibration of various instruments and the of the sounds yielded by them.

Light.

iments and apparatus employed in teaching, and in the ations and observations connected with:—
uction.—Combustion, Electric discharge, &c.
urement of Intensity, Velocity.
n of Matter on Light.—Reflection, Refraction, Dispersion, atism, Direct vision prisms, Polarization, Absorption , Fluorescence, &c.
n of Light on Light.—Interference, Diffraction, Measure- wave length (optical banks), &c.
n of Light on Matter.—Photography, Radiometry, Phos- ence, &c.
ical Applications of Optical Principles.—Lighthouse— tion, &c.

Heat.

iments and apparatus employed in teaching, and in the ations and observations connected with:—
es of Heat.—Chemical, Electrical, Dynamical, Solar, ence, &c.
ts of Heat on Matter.—Changes of Temperature, Expan- l change of Elasticity, Liquefaction, Vaporization, &c.
urement of Temperature.—Thermometers, Pyrometers,

agation of Heat.—Radiant Heat,—Radiometer, Re- Refraction, Radiation, Absorption, Polarization; Conduc- Solids, Liquids, Gases; Convection,—Ventilation, &c.
t of change of Molecular State on Temperature.—Freez- tures, Ice machines, &c.
t of change of Pressure and Volume.
Quantity.—Unit of Heat, Calorimeters, Specific Heat, &c. s of determining Latent Heat.
anical Equivalent of Heat.—Methods of determining. ions of Thermodynamics.

[illegible]

[illegible] —[illegible] of [illegible]ining.

[illegible]

[illegible] and in
[illegible]

[illegible] Magnet[illegible]. C
[illegible]

[illegible] and in
[illegible] Galva[illegible]
[illegible] Machi[illegible]
[illegible] Che[illegible]
[illegible] force. M[illegible]
[illegible] Accum[illegible]
[illegible] on co[illegible]
[illegible] Galvan[illegible]
[illegible] &c.
[illegible] comparing
[illegible] British
[illegible] light, heat,
[illegible] magnets, soft iron
[illegible] telegraph, &c.

Astronomy.

ips, catalogues, globes, orreries, &c.
n instruments.
ments for communicating true time.
uths, zenith-sectors, sextants, &c.
cal Telescopes { Reflectors.
{ Refractors.
ters.
clocks.
rrangements for—
estial photography.
ctroscopic observations.
rmo-electric observations.
its.

Applied Mechanics.

xhibition must be regarded as chiefly referring to edu-
arch, and other scientific purposes, it must in this
nsist principally of models, diagrams, mechanical draw-
nall machines, illustrative of the principles and progress
al science, and of the application of mechanics to the

s of Materials.
s at Rest and in Motion.
overs.
rs of Energy.
rs.
lication of the Principles of Mechanics to Machinery
he Arts.
, Naval Architecture, and Marine Engineering.

Chemistry.

instruments, apparatus, and materials employed in the
n and teaching of Chemical Science, and in the appli-
principles to scientific purposes.
s and models.
ns of analytical results.
s of chemicals,—(*a*) organic, (*b*) mineral.
s and fittings for laboratory and lectures.
s for gravimetric and volumetric operations.
s for distillation and filtration.
s for operations by the dry or hot method, such as
wpipe, &c.
tory apparatus.
s for spectrum analysis.

Mr.

LIST OF CONTRIBUTORS, WITH ADDRESSES.

**** The numbers refer to the Sections of the Catalogue.*

UNITED KINGDOM.

...bel, F. A., F.R.S., *Royal Arsenal, Woolwich*, 10.

...bercromby, Hon. R., 21, *Chapel Street, Mayfair, London*, 14.

...ney, Capt. W. de W., R.E., *Chat-...am*, 7, 11, 14.

...raham, C., *University of Edin-...rgh*, 13.

...and, Dr., F.R.S. *on behalf of the ...dcliffe Trustees, Oxford*, 16.

...ms, Prof. A. L., M.A., F.R.S., *...yal College of Science, Dublin*, ...

..., P., 15, *Pall Mall, London*, 3, ... 15, 16.

...ralty (Hydrographic Depart-...t), *Whitehall, London*, 3, 9, ...

...autical Society of Great ...ain (*F. W. Brearey, Hon.* ..., *Maidenstone Hill, Green-...* 14.

...ltural Society of Eng-... Royal, 12, *Hanover Square*, ...s, 12.

...ker, H. C., 117, *Stamford ... London*, 3.

..., Tyssen, 12.

...cal Department, *Oxford ...ity Museum*, 18.

..., Dr., F.R.S., *Queen's Col-...fast*, 5, 8, 10, 13.

... W., *Indo-European Te-... Company, Old Broad* ...0.

...433, *Strand, London*, 7, ...

... J. and W. E., 201, *...er Bridge Road, London*, ...

...Mander, 25, *Old Comp-... Soho, London*, 1, 3.

Astronomer Royal, The (Sir G. B. Airy, K.C.B., F.R.S.), *Greenwich, London*, 11.

Astronomical Society, Royal, *Burlington House, Piccadilly, London*, 11.

Austin and Hunter, *Sunderland*, 12.

Autotype Company, 36, *Rathbone Place, London*, 7, 11.

Aveling and Porter, 72, *Cannon Street, London; and Rochester*, 12.

Babbage, Major-General, 1.

Badden, E. R., *Elm Villa, Horn Lane, Acton*, 18.

Baden-Powell, Mrs., 1, *Hyde Park Gate South, London*, 7.

Bagot, A. C., *Pembroke College, Cambridge*, 10.

Bailey, W. H., & Co., *Albion Works, Salford, Manchester*, 3, 8, 12.

Ball, R. S., LL.D., F.R.S., *Royal Astronomer of Ireland, The Observatory, Dunsink, co. Dublin*, 2.

Barker, R. E., *Clifton, Bristol*, 15.

Barlow, W. H., F.R.S., *High Combe, Old Charlton, S.E.*, 6.

Barrett, Prof. W. F., F.C.S., *Royal College of Science, Dublin*, 5, 6, 7, 8, 9, 10, 12, 15, 21.

Bashforth, Rev. F., *Minting Vicarage, Horncastle, Lincolnshire*, 3.

Bassett, H., 44, *St. Paul's Road, Camden Town, London*, 6.

Beck, J., 31, *Cornhill, London*, 18.

Beck, R. and J., 31, *Cornhill, London*, 18.

Bel, A., & Co., 34, *Maiden Lane, Strand, London*, 6, 13, 19.

Belcher, Admiral Sir E., K.C.B., 13, *Dorset Street*, 12.

Bell, J., *Rushpool, Saltburn-by-Sea*, **16**.

Bidder, S. P., 24, *Great George Street, Westminster*, **16**.

Bird, P. H., F.R.C.S., 1, *Norfolk Square, London; and Lytham, Lancashire*, **8**.

Blake, H. Wollaston, F.R.S., 8, *Devonshire Place, Portland Place, London*, **11**.

Board of Works, *London*, **1, 18**.

Bonomi, J., 13, *Lincoln's Inn Fields, London*, **18**.

Bosanquet, R. H. M., *St. John's College, Oxford*, **6**.

Bowling Iron Company, *Bowling, Bradford, Yorkshire*, **13**.

Bracey, J., *Yarmouth, Norfolk*, **12**.

Brady, Rev. Nicholas, M.A., *Rainham Hall, Romford, Essex*, **7, 13, 17**.

Brighton Free Library and Museum, *Brighton*, **16**.

Brion, H. F., 281, *Albany Road, London*, **15, 16**.

Bristol Museum and Library, *Bristol*, **15, 16**.

Bristow, H. W., F.R.S., *Director, Geological Survey for England and Wales, Jermyn Street, London*, **16**.

British Horological Institute, 35, *Northampton Square, London*, **3**.

British Telegraph Manufactory, 374, *Euston Road, London*, **10**.

Brodie, Sir B. C., Bart., *Brockham Warren, Reigate*, **13**.

Brooke, C., F.R.S., 16, *Fitzroy Square, London*, **4, 9, 14, 17**.

Brooke, Mrs. Croft, *Tunbridge Wells*, **12**.

Brooke, Simpson, and Spiller, 50, *Old Broad Street, London*, **13**.

Brown, Prof. A. Crum, *University of Edinburgh*, **13, 17, 18**.

Browning, John, 63, *Strand, London*, **7, 10, 11, 15, 18**.

Brunton, T. L., F.R.S., **18**.

Burgh of Stirling, The, *Stirling, Scotland*, **3**.

Burt, T., *Society for Promoting Christian Knowledge*, 77, *Great Queen Street, London*, **16**.

Busk, G., 32, *Harley Street*, **18**.

Butler, P. J., 55, *De Beauvoir Road, London*, **3**.

Calvert, F. C., & Co., *Tower Chemical Works, Bradford, near Manchester*, **13**.

Campbell, Lieut.-Col. A. C. (*of Blythswood*), 2, *Seamore Place, Mayfair, London*, **11**.

Cann-Lippincott, R. C., jun., *Overcourt, Bristol*, **14**.

Casartelli, J., 43, *Market Street, Manchester*, **3, 8, 15, 16**.

Casella, L., 147, *Holborn Bars, London*, **11, 14, 15**.

Cator, C. O. F., M.A., *The Hall, Beckenham, Kent*, **14**.

Caulfield, R., LL.D., F.S.A., *Queen's College and Royal Institution, Cork*, **15**.

Cayley, Prof., F.R.S., *Garden House, Cambridge*, **2**.

Cetti, E., & Co., 11 *and* 31, *Brooke Street, Holborn, London*, **5, 8, 10, 13, 14, 16, 18**.

Chance Brothers & Co., *Birmingham*, **7, 11**.

Chappe de Leonval, T. F., 29, *Stanley Gardens, Notting Hill Gate, London*, **3**.

Chappell, W., F.S.A., 49, *New Bond Street, London*, **6**.

Chatham, *School of Military Engineering*, **7, 10, 15**.

Chesney, Col. G., *Royal Indian Engineering College, Cooper's Hill, Staines*, **12**.

Chisholm, H. W., Warden of the Standards, 7, *Old Palace Yard, London*, **3**.

Christy, T., & Co., 155, *Fenchurch Street, London*, **5**.

Church, Prof. A. H., *Agricultural College, Cirencester*, **3**.

Clare, T. D., *Heathfield Place, Handsworth, Birmingham*, **16**.

Clark, Latimer, 5, *Westminster Chambers*, **10**.

Clifton, R. B., F.R.S., *Clarendon Laboratory, University Museum Oxford*, **6, 11**.

Cole, A. C., and Son, 62, *St. Domingo Vale, Everton, Liverpool*, **18**.

College of Surgeons, Royal, *Lincoln's Inn Fields, London*, **18**.

Commissioners of Northern Lighthouses, *Edinburgh*, **12**.

Commissioners of Patents, *Patent Office Museum, South Kensington, London*, **1, 3, 9, 12**.

COODE, SIR J., 2, *Westminster Chambers, London*, **12**.

COOKE, C. W., C.E., *M. Inst., T. E.*, 190, *Westminster Bridge Road, London*, **10**.

COWPER, E. A., 6, *Great George Street, Westminster*, **8**, **12**.

CRAMPTON, T. R., 4, *Victoria Street, Westminster*, **10**.

CRIPPS, W. H., F.R.C.S., 53*a*, *Pall Mall, London*, **14**.

CRISP, F., 134, *Adelaide Road, London*, **18**.

CROSSLEY BROTHERS, *Great Marlborough Street, Manchester*, **12**.

CROSSLEY, E., F.R.A.S., *Bermerside, Halifax*, **3**.

CROUCH, H., 66, *Barbican, London*, **18**.

CULLEY, R. S., *General Post Office, London*, **10**.

CURTIS, PROF. A. H., LL.D., *Queen's College, Galway*, **7**.

CURWEN, J., *Plaistow, Essex*, **6**.

COTTELL, F. G., 52, *New Compton Street, Soho, London*, **16**.

DAGLISH, R., & Co., *St. Helen's, Lancashire*, **12**.

DALE, R. S., B.A., *Owens College, Manchester*, **13**.

DALLAS, D. C., 362, *Gray's Inn Road, London*, **7**.

DALLINGER, REV. W. H., F.R.M.S., 4, *Fairholme Road, Great Crosby, Liverpool*, **18**.

DALLMEYER, JOHN H., 19, *Bloomsbury Street, London*, **7**.

DALLMEYER, JOSEPH H., **7**.

DAMON, R., *Weymouth*, **16**, **18**.

DARLING, W. H., *Owens College, Manchester*, **13**.

DARTON, F., & Co., 72, *St. John Street, West Smithfield, London*, **14**.

DARWIN, G. H., *Trinity College, Cambridge*, **15**.

DAVIDSON, J., *University of Edinburgh*, **13**.

DAVIS, CAPT. J. E., R.N., F.R.G.S., *Douglas House, Maze Hill, Greenwich*, **11**, **15**.

DAVIS, J., AND SON, *Derby*, **3**, **16**.

DEACON, H., *Widnes, Lancashire*, **13**.

DENT, E., **3**, **11**.

DENT, E., & Co., 61, *Strand, London*, **3**, **11**.

DE LA RUE, W., F.R.S, 73, *Portland Place, London*, **7**, **10**, **11**.

DE MICHELE, V., *Higham Hall, Rochester*, **3**.

DENTON, S.G., 128, *Gray's Inn Road, Holborn, London*, **8**.

DENTON, W., *Sunderland*, **12**.

DE RANCE, C. E., F.G.S., *Geological Survey, Jermyn Street, London*, **16**.

DE RATTI, A., *Bradford Grammar School, Bradford, Yorkshire*, **10**.

DEWAR, PROF., *Cambridge*, **10**.

DIXON, A., *St. Anne's, Howard Road, Penge, Surrey*, **11**.

DONKIN, A. E., M.A., *Rugby*, **2**.

DOWNING, T. J., 38, *Whiskin Street, London*, **16**, **17**, **19**.

DOXFORD, W., AND SONS, *Sunderland*, **12**.

DRING AND FAGE, 19 & 20, *Tooley Street, London*, **1**, **5**, **8**.

DRYSDALE, J. J., 4, *Fairholme Road, Great Crosby, Liverpool*, **18**.

DUER, S., B.Sc., 6, *Westminster Chambers, Victoria St., London*, **12**.

DUNSCOMBE, M. W., 10, *St. Augustine's Parade, Bristol*, **19**.

EAMES, M., 40, *Sclater Street, Shoreditch, London*, **2**.

EDINBURGH MUSEUM OF SCIENCE AND ART, *Edinburgh*, **7**, **8**, **9**, **10**, **13**.

EDINBURGH UNIVERSITY, *Edinburgh*, **8**, **9**, **10**, **11**, **12**, **14**.

EDWARDS, B. J., & Co., 6, *Lincoln Terrace, Kilburn, London*, **7**.

ELDER, J., & Co., *Govan, near Glasgow*, **12**.

ELKINGTON & Co., 22, *Regent Street, London*, **10**.

ELLIOTT BROTHERS, 449, *Strand, London*, **1**, **3**, **4**, **6**, **7**, **8**, **9**, **10**, **11**, **12**, **14**, **15**, **16**.

ENOCK, F., 30, *Russell Road, Holloway*, **18**.

ERARD, MESSRS., 18, *Great Marlborough Street, London*, **6**.

ESSEX AND CHELMSFORD MUSEUM, *Chelmsford*, **18**.

EVANS, L., *Hemel Hempsted*, **1**, **2**.

FAIJA, H., 4, *Great Queen Street, Westminster*, **1**, **12**.

FARADAY, MRS., *Barnsbury Villa*, 320, *Liverpool Road, London*, **10**, **13**.

FARWIG, J. F., 36, *Queen Street, Cheapside, London*, **8**.

Reynolds, Prof. O., *Owens College, Manchester*, **2**, **3**.

Richardson, Duck, & Co., *Stockton-on-Tees*, **12**.

Ritchie, J., & Son, 25, *Leith Street, Edinburgh*, **11**.

Roberts, W. H., *Snodland, Kent*, **15**.

Roberts, W. Chandler, F.R.S., *Royal Mint, London*, **7**, **13**.

Roberts, Dale, & Co., *Manchester and Warrington*, **13**.

Rolleston, Prof., F.R.S., *Oxford University Museum*, **18**.

Roscoe, Prof., F.R.S., *Owens College, Manchester*, **7**, **13**, **14**.

Ross and Co., 7, *Wigmore Street, Cavendish Square, London*, **7**, **18**.

Rosse, Earl of, F.R.S., *Birr Castle, Parsonstown, Ireland*, **11**.

Round, J., 196, *Camberwell Road, London*, **10**.

Rowley, W., C.E., F.G.S., 74, *Albion Street, Leeds*, **16**.

Royal Agricultural Society of England, 12, *Hanover Square, London*, **12**.

Royal Astronomical Society, *Burlington House, Piccadilly, London*, **11**.

Royal College of Science for Ireland, *Stephen's Green, Dublin*, **1**, **12**. *See also* Professors Adams, Barrett, Galloway, Hennessy, Hull, McNab, O'Reilly, and Pigot.

Royal College of Surgeons of England, *Lincoln's Inn Fields, London*, **18**.

Royal Geographical Society of London, 1, *Savile Row, Burlington Gardens, London*, **15**.

Royal Institution of Great Britain, 21, *Albemarle Street, London*, **8**, **9**, **10**, **12**, **13**, **16**.

Royal Microscopical Society, *King's College, London*, **12**, **18**.

Royal Museum, Salford, *Peel Park, Salford*, **1**, **3**, **7**, **9**, **11**, **12**, **14**, **18**.

Royal Naval Museum, *Greenwich, London*, **3**, **11**, **12**, **15**.

Royal School of Mines, *Jermyn Street, London*, **3**, **12**.

Royal Society, *Burlington House, Piccadilly, London*, **3**, **5**, **9**, **11**, **15**, **16**.

Royal United Service Institution, *Whitehall Yard, London*, **3**, **11**.

Roydon, W., *Liverpool*, **12**.

Royston-Pigott, G. W., M.D., F.R.S., *Hartley Court, Reading*, **3**, **18**.

Rücker, Prof. A. W., M.A., *Yorkshire College of Science, Leeds*, **3**.

Ruhmkorff, 11, *Beak Street, Regent Street*, **10**.

Rutherford, Prof., *Edinburgh*, **18**.

Rutley, F., *Geological Survey Office, Jermyn Street, London*, **16**.

Rutter, J. O. N., F.R.A.S., *Black Rock, Brighton*, **9**.

Sabine, R., 25, *Cumberland Terrace, Regent's Park, London*, **6**, **7**, **10**.

Salford Royal Museum, *Peel Park, Salford*, **1**, **3**, **7**, **9**, **11**, **12**, **14**, **18**.

Samuelson, B., M.P., *Middlesborough*, **13**.

Sanderson and Proctor, *Shore Works, Huddersfield, and* 19 *and* 21, *Queen Victoria Street, London*, **8**, **10**.

Schorlemmer, C., F.R.S., *Owens College, Manchester*, **13**.

Scotland, Geological Survey of, *Edinburgh*, **16**.

Scott, M., 9, *Great Queen Street, Westminster*, **12**.

Scott, R. H., F.R.S., *Director, Meteorological Office*, 116, *Victoria Street, Westminster*, **14**.

Scottish Meteorological Society, *General Post Office Buildings, Edinburgh*, **7**, **14**.

Secretary of State for India, *India Office, Whitehall, London*, **15**.

Shand, Mason, & Co., 75, *Upper Ground Street, London*, **12**.

Sharman, G., *St. Leonard's Villa, West End Lane, Kilburn, London*, **16**.

Siebe and Gorman, *Mason Street, Westminster Bridge Road*, **12**.

Siemens, Dr. C. W., *London*, **3**, **8**.

Simey, A., & Co., *Sunderland*, **12**.

Sinclair, J., 104, *Leadenhall Street, London*, **12**.

Skertchly, Sydney B. J., F.G.S., *Geological Survey, Jermyn Street, London*, **14**.

Skinner, *Sunderland*, **12**.

Smith, Edwin, *Bath*, **11**.

T. AND W., *Newcastle-on-* **12**.
V., C.E., *Newcastle-on-Tyne*,

I., JUN., M.I.C.E.I., *Milltown, idge, Ireland*, **13**, **14**.
PROF. PIAZZI, *Royal Obser-, Edinburgh*, **3**, **7**, **8**.
LLE, J., 20, *Westland Row*, **12**.
H. C., F.R.S., *Broomfield, eld*, **16**, **18**.
KENSINGTON MUSEUM, *Lon-*, **6**, **7**, **10**, **12**.
.Y, H., 43, *King's Road, St. as, London*, **6**.
P., *Pendleton Alum Works, hester*, **13**.
, J., F.C.S., 2, *St. Mary's Canonbury, London*, **7**.
WOODE, W., F.R.S., 50, *Gros- Place, London*, **7**.
WOODE, MRS. W., 50, *Gros- Place, London*, **7**.
, J. T., 315, *Green Lane, ngham*, **10**.
L, H., 44, *Charlwood Street, o, London*, **5**, **13**.
RDS DEPARTMENT, BOARD OF E (H. W. Chisholm, War- 7, *Old Palace Yard, Lon-* .
ID, E., *Charing Cross, Lon-*, **6**.
, W. F., 3, *Great Turnstile, rn, London*, **2**.
, G., *Morpeth, Northumber-* **12**.
SON, J. W., *Equitable As- e Office, Mansion House , London*, **18**.
SON, D. & T., *Northern Light- Office, Edinburgh*, **12**.
T, PROF. BALFOUR, F.R.S., *College, Manchester*, **8**.
ND SONS, *London Pottery, eth*, **13**.
G, THE BURGH OF, *Stirling*, **3**.
DR. W. H., *Dean's Yard, minster*, **4**, **6**, **7**, **9**, **11**, **17**, **18**.
ERS, PROF., *Aberdeen Uni- y*, **18**.
ALDEN EXPLORATION COM- E (W. Topley, F.G.S., and illett, F.G.S.), **16**.
W., *Vincent Works, Vincent , Westminster*, **7**.

SULLIVAN & Co., *British Alkali Works, Widnes, Lancashire*, **13**.
SUNDERLAND, CORPORATION OF, **12**.
SWIFT, J., 43, *University Street, Tottenham Court Road, London*, **18**.
SYMONS, G. J., 62, *Camden Square, London*, **9**, **14**, **15**.
TAIT, PROF. P. G., M.A., *University of Edinburgh*, **8**, **10**.
TALBOT, H. FOX, F.R.S., *Lacock Abbey, Chippenham*, **7**.
TANGYE BROTHERS, AND HOLMAN, 10, *Laurence Pountney Lane, London*, **12**.
TAYLOR, MAJOR M. L., R.A., *Royal Artillery Institution, Woolwich*, **3**, **15**.
THAMES IRON WORKS AND SHIPBUILDING Co., *Orchard Yard, Blackwall*, **12**.
THAMES IRON WORKS Co., *Millwall*, **12**.
THERMO-ELECTRIC GENERATOR Co., 27, *New Street, Cloth Fair, London*, **10**.
THOMAS, J. W., *The Laboratory, Cardiff, Wales*, **12**.
THOMSON, PROF. SIR W., F.R.S., *The University, Glasgow*, **1**, **3**, **4**, **10**, **12**, **15**.
THOMPSON, J. L., AND SONS, *Sunderland*, **12**.
THOMPSON, R., Junr., *Sunderland*, **12**.
THORPE, PROF., *Leeds*, **7**, **13**.
THWAITES AND CARBUTT, *Bradford, Yorkshire*, **12**, **13**.
TISLEY AND SPILLER, 172, *Brompton Road, London*, **4**, **10**, **14**.
TOPLEY, W., F.G.S., *Geological Survey, Jermyn Street, London*, **16**.
TRIBE, A., 17, *Pembridge Square, London*, **13**.
TRINITY COLLEGE, DUBLIN, *Dublin*. (*See* JELLETT AND LLOYD.)
TRINITY HOUSE, LONDON, CORPORATION OF, *Trinity Square, Tower Hill, London*, **12**.
TROUGHTON AND SIMMS, 138, *Fleet Street, London*, **3**, **11**, **15**.
TYLER HAYWARD & Co., 84, *Upper Whitecross Street, London*, **12**.
TYLOR, J., AND SONS, 2, *Newgate Street, E.C.*, **3**, **12**.
TYNDALL, PROF., F.R.S., 21, *Albemarle Street, London*, **6**, **8**, **9**.
UNITED SERVICE INSTITUTION, ROYAL, *Whitehall Yard, London*, **3**, **11**.

University of Edinburgh, *Edinburgh*, **8, 9, 10, 11, 12, 14.**

University of Oxford Museum, *Oxford*, **16, 18.**

Unwin, Prof. W. C., *Cooper's Hill College, Staines*, **3.**

Varley, S. A., *Hatfield, Herts*, **10.**

Wallace, J. (Tangye Brothers & Rake), 3, *St. Nicholas Buildings, Newcastle-upon-Tyne*, **13.**

Walter, J., M.P., 40, *Upper Grosvenor Street, London*, **12.**

War Office, *Pall Mall, London*, **3, 10.**

Ward, J. Clifton, *Greta Bank Cottage, Keswick*, **16.**

Ward, W. S., *Denison Hall, Leeds*, **5, 10, 13, 15, 18.**

Warden, Muirhead, and Clark, 29, *Regent Street, Westminster, London*, **10.**

Warwick, T. A., *Derby*, **10.**

Waterhouse, A., 20, *New Cavendish Street, London*, **21.**

Watkin, Lieut. H., R.A., 1, *Uxbridge Villa, Paget Road, Shooters Hill, London*, **3.**

Watson and Son, 313, *High Holborn, London*, **11, 15.**

Wear, Commissioners of the River, *Sunderland*, **12.**

Webb, F. W., *Locomotive Department, L. and N. W. Railway, Crewe*, **12.**

Wedekind, H., 4, *Great Tower Street, London*, **13.**

Wheatstone Collection of Physical Apparatus, *King's College, London*, **4, 7, 9, 10, 11.**

Wheeler, E., 48, *Tollington Road, Holloway, London*, **18.**

White, J., 241, *Sauchiehall Street, Glasgow*, **10.**

White, J., *Cowes, Isle of Wight*, **12.**

Whitwell, T., *Stockton-on-Tees*, **13.**

Whitworth, Sir Joseph, F.R.S., & Co., 44, *Chorlton Street, Manchester*, **3, 13.**

Widnes Metal Co., *West Bank, Widnes, Lancashire*, **13.**

Willett, H., F.G.S., *Arnold House, Brighton*, **16.**

Williams, J., F.C.S., 16, *Cross Street, Hatton Garden, London*, **8.**

Willis, W., 49, *Palace Grove, Bromley, Kent*, **7.**

Willis, W., Junr., 73, *Monument Lane, Edgbaston, Birmingham*, **7.**

Wiltshire, Rev. T., M.A., *Secretary, Geological Society, Burlington House, Piccadilly, London*, **16.**

Winchester, Corporation of, *Winchester*, **3.**

Wollaston, G. H., 117, *Pembroke Road, Clifton, Bristol*, **6, 7, 13, 17.**

Wood, G. S., 20, *Lord Street, Liverpool*, **18.**

Wood, J., *Ivy Cottage, Burnley Lane*, **12.**

Woodbury Permanent Photographic Printing Co., 157, *Great Portland Street, London*, **7.**

Woodcroft, Bennet, F.R.S., *Great Seal Patent Office, London*, **1, 2, 3, 9, 12.**

Woodward, C. J., *Birmingham and Midland Institute, Birmingham*, **4, 7.**

Works, H.M. Office of, *London*, **1, 18.**

Wornum and Sons, 16, *Store Street, London*, **6.**

Wortley, Col. Stuart, *Patent Museum, South Kensington, London*, **7.**

Wrightson, T., *Sunderland*, **12.**

Yeates and Son, 2, *Grafton Street, Dublin*, **6, 7, 8, 10, 11, 14.**

Young, J., *West Docks, South Shields*, **12.**

Yorkshire College of Science, Council of, *Leeds*, **1, 3, 4, 13.**

Yorkshire Philosophical Society, Council of, *York*, **11.**

Zanni, G., 31, *Compton Road, Highbury, and* 1, *James Street, Old Street, City Road, London*, **10.**

Zoological Society of London, 11, *Hanover Square, London*, **18.**

AUSTRO-HUNGARIAN EMPIRE.

Arzberger, Prof. F., *Imp. & Royal Technical High School, Brünn*, **13, 15.**

Bauer, Prof. Dr. A., *Polytechnic Institute*, 20, *Kamtnerstrasse, Vienna*, **8, 13.**

r, Dr. E., *Prof. of Mineral-*
Iniversity of Prague, **17**.
hausen, Baron C., *Prof. of*
y, *University of Gratz*, **16**.
Dr. W. F., *Professor of*
eering, High School of Agri-
and Forestry, Vienna, **12**.
, Imp. and Royal Institu-
for carrying out Experi-
relating to (Dr. W.
a, Physiologist to the Institu-
Vienna, **18**.
., *Prague*, **18**.
nn, Ed., *Vienna*, **1**.
n, Prof. M., *University of,*
-Pest, **16**.
rtner, Lieut. F. (*Imp. and*
Navy), *Vienna*, **15**.
Royal Central Institute
teorology and Magnetism,
, **3**, **14**.
d Royal Institution for
iments relating to
ts, *Vienna*, **18**.
Royal Maritime Govern-
Trieste, **12**.
e of Pathology, *Univer-*
Vienna (Prof. S. Stricker,
or), **18**.
., *Professor, Imp. and Royal*
chnic Institute, Vienna, **3**.
, Prof. Dr. A., **3**.
rof. V. von, *University of*
, **4**.
ology and Magnetism,
nd Royal Central Insti-
of, *Vienna*, **3**, **14**.
F., *Innsbruck*, **15**.
Prof. I., *Director of the*
and Royal Chemical Institu-
or Agricultural Researches,
a, **13**.
, Prof. F., *Imp. and Royal*
l Institute of Meteorology,
Warte, Vienna, **3**, **14**.
gy, Institute of, *Univer-*
Vienna (Prof. S. Stricker,
or), **18**.
, Dr. F., *Director of the*
and Royal Commercial and
al Academy, Trieste, **14**.
er, Dr. L., *Prof. of*
s, University of Innsbruck,

ogical Institute, *Prague*,

Prague, Pathological Institute of the University of (Dr. E. Klebs, Director), **18**.

Roesler, Prof. Dr. L., *Director of the Imp. and Royal Experimental Station for the Cultivation of the Vine and Fruits, Klosterneuburg*, **13**, **18**.

Scherzer, Dr. K. von, *Austrian Consulate General*, 29, *St. Swithin's Lane, London*, **15**.

Schlesinger, Prof. J., *High School of Agriculture, Vienna*, **15**.

Schoen, Prof. J. G., *Polytechnic Institute, Brünn*, **14**.

Streintz, Prof. Dr. H., *University of Gratz*, **3**.

Stricker, Prof. S., *University of Vienna* (*Institute of Pathology*), **18**.

Szabo, Prof. Dr. J., *University of Buda-Pest*, **16**.

Tille, J., Prof., *Bohemian Polytechnic Institute, Prague*, **12**.

Tilser, Prof. F., *Bohemian Polytechnic Institute, Prague*, **2**.

Trieste, Imperial and Royal Maritime Government at, **12**.

University of Vienna, Institute of Pathology, **18**.

Velten, Dr. W., *Imp. and Royal Institution for carrying out experiments relating to Forests, Vienna*, **18**.

Vienna, Imp. and Royal Central Institute of Meteorology and Magnetism, **3**, **14**.

Vienna, Imp. and Royal Institution for Experiments relating to Forests, **18**.

Vienna University, Institute of Pathology, **18**.

Waltenhofen, Dr. A. von, *Prof. of Physics, German Polytechnic Institution, Prague*, **9**.

Zenger, C. W., *Prof. of Physics, Bohemian Polytechnic Institution, Prague*, **3**, **7**, **10**, **11**, **18**.

Zmurko, Dr. L., *Prof. of Mathematics, University, and Polytechnic Institute, Lemberg*, **2**.

Zulkowsky, Prof. C., *Imp. and Royal Technical High School, Brünn*, **13**.

ue, *Paris*, 3, 5,
de Rambouillet,
Rue St. Fiacre,
0, 15.
es, *Paris*, 5, 8.
, *Paris*, 7.
DE L'INSTITUT,
ille Estrapade,
ue St. Georges,
M., 122, *Boule-*
se, Paris, 3.
FOR OBSERVING
NUS IN 1874, 11.
i des Orfevres,
ris, 7.
, *Conservatoire*
, 292, *Rue St.*
, 7.
ontreuil, Paris,
Rue de Vienne,
RT, 102, *Rue*
ns, Paris, 10.
OCH, *Paris*, 15.
5, *Rue de Lis-*
bach, Colmar, 3.
13.
Rue St. Maur,
inne, Paris, 8.
e l'Institut, 33,
11.
COLLÉGE DE
nbrai, Paris, 13.
, *Rue de Lille*,
te, Caen, 15.
8, 18.
ROF., CONSERVA-
S ET MÉTIERS,
4, *Rue Taitbout*,
Rue Richelieu,

LUIZARD, 48, *Rue St. André des Arts, Paris*, 5, 7, 8, 10.
LUTZ, *Paris*, 3, 7, 11, 17, 18.
MALLIGAND FILS, 1, *Boulevard St. Michel, Paris*, 18.
MANNHEIM, PROF., *Ecole Polytechnique, Paris*, 1.
MARIAIS, 260, *Rue St. Honoré, Paris*, 10.
MAREY, PROF. (*Collegé of France*), 18, *Rue Dugay Trouin, Paris*, 18.
MASCART, PROF. (*College of France*), *Paris*, 7.
MATHIEU, *Paris*, 18.
MOLTENI, T. AND A., 44, *Rue du Chateau d'Eau, Paris*, 2, 7, 11, 15.
MOURET, 8, *Cour des Petites Ecuriés* (*Redier*), *Paris*.
NACHET, A., 17, *Rue St. Séverin, Paris*, 7, 18.
NAVEZ, *Paris*, 3.
OBSERVATORY OF PARIS, 7, 11.
ORSAT, *Paris*, 18.
PARIS, VICE-ADMIRAL, *President de l'Académie des Sciences, Paris*, 12.
PHARES DE FRANCE, SERVICE DES, *Place du Trocadéro, Paris*, 12.
PHOTOGRAPHIC SOCIETY, *Paris*, 7.
PICART, A., 20, *Rue Mayet, Paris*, 18.
POLYTECHNIC SCHOOL, *Paris*, 3, 5, 6, 7, 8, 9, 10.
REDIER, *Paris*, 3, 10, 14.
RENAUD TACHET, MM., 17, *Rue Richelieu, Paris*, 1, 2.
RICHARD, *Paris*, 14.
ROULOT, *Paris*, 18.
RUHMKORFF, 15, *Rue Champollion, Paris*, 8, 10.
SCHOOL OF PHARMACY, *Paris*, 7.
SCIENCES, FACULTÉ DES, *Paris*, 5, 8.
SEGUIER, M. LE, 3, *Rue du Régard, Paris*, 12.
SERVICE DES PHARES DE FRANCE (Lighthouse Service of France), *Place du Trocadéro, Paris*, 12.
SOCIÉTÉ DE L'ALLIANCE, LA, 25, *Rue Dufrenoy, Paris*, 10.
SOCIÉTÉ DES VOYAGES D'ÉTUDES AUTOUR DU MONDE, 10, *Rue du Mont Thabor, Paris*, 15.
SOCIÉTÉ FRANÇAISE DE PHOTOGRAPHIE, 20, *Rue Louis le Grand, Paris*, 7.
TAVERNIER GRAVET, *Paris*, 1, 3, 15.
TELEGRAPH DEPARTMENT, *Paris*, 10.

THIEL, *Paris*, **7**.
TONDOLA & Co., *Paris*, **3**.
TRAMONT, 9, *Rue de l'École de Médecine, Paris*, **18**.
TRESCA, H. E., *Membre de l'Académie des Sciences, Sous-Directeur du Conservatoire des Arts et Métiers, Paris*.
TROUVÉ, G., 6, *Rue Thérèse, Paris*, **10, 18**.
VIDAL, L., 13, *Quai Voltaire, Paris*, **7**.
VILLARCEAU, I., *Membre de l'Institut*, 18, *Avenue de l'Observatoire, Paris*, **3**.
WENTZEL, MADAME, 6, *Rue Bretonviller, Paris*, **2**.
WERLEIN, *Paris*, **2, 17, 18**.
WIESNEGG, 64, *Rue Gay Lussac, Paris*, **13**.
WINKEREL, 35, *Galerie Montpensier (Gabriel), Paris*, **3**.

GERMANY.

ACADEMY OF MINES, ROYAL (Prof. Hauchecorne, Director), *Berlin*, **12, 16**.
ACADEMY OF MINES, ROYAL (Prof. Richter, Director), *Freiberg, Saxony*, **10, 12, 13, 16, 17**.
ADMIRALTY, IMPERIAL, HYDROGRAPHIC DEPARTMENT AND NAUTICAL OBSERVATORY, *Berlin and Hamburg*, **8, 9, 14, 15**.
ALBERT, J. W., 34, *Neue Mainzerstrasse, Frankfort-on-Maine*, **6, 7**.
ALBRECHT, *Tübingen*, **6, 17**.
ALTHAUS, E., *Superintendent of Mines, Breslau*, **8**.
APEL, W., *Göttingen*, **7, 14, 17**.
APPUUN, G., AND SONS, *Hanau*, **6**.
ASSOCIATION FOR THE MANUFACTURE OF ANILINE, *Berlin*, **13**.
AUGUST, DR. F., *Humboldt-Gymnasium, Berlin*, **11**.
BABO, PROF. von (Chemical Laboratory), *Freiburg, Breisgau*, **6**.
BACH, DR. O., *Leipzig*, **13**.
BAEYER, LIEUT.-GENERAL (President of the Geodetic Institute), *Berlin*, **3, 15**.
BALL, *Freiburg, Breisgau*, **13**.
BAMBERG, C., 158, *Linienstrasse, Berlin*, **3, 9, 11, 14, 15**.
BAU-DEPUTATION, *Hamburg*, **15**.
BAUER, PROF. DR. A., *Polytechnic Institute, Vienna*, **8**.
BAUERNFEIND, PROF. DR. von (Geodetic Institute, Royal Polytechnic School), *Munich*, **15**.
BAUR AND HAEBE, *Stuttgart*, **10, 14**.
BECKER, AUG. (DR. MEYERSTEIN'S Workshops), *Göttingen*, **7, 18**.
BEETZ, PROF. DR. (Polytechnic School), *Munich*, **3, 8, 10, 18**.
BERGGEWERKSCHAFTSKASSE (Dr. Heintzmann), *Bochum*, **3, 11, 12, 13, 16, 19**.
BERLIN, PHYSICAL INSTITUTION OF (Dr. Helmholtz), **9**.
BERNSTEIN, A., AND CO., 50, *Markgrafen Strasse, Berlin*, **3**.
BERNSTEIN, PROF. (Director), *Physiological Institute, University of Halle*, **3**.
BEZOLD, PROF. W. von (Polytechnic School), *Munich*, **3, 7, 10**.
BIEDERMANN, DR. R., *Berlin*, **13**.
BLATTNER, C. (Polytechnic School), *Munich*, **7**.
BLATZBECKER, DR. A. A., *Cologne*, **13**.
BOCK AND HANDRIK, 2, *Falkenstrasse, Dresden*, **2, 12**.
BOHN, PROF. DR., *Aschaffenburg*, **5, 14**.
BONSACK, A., *Berlin*, **3, 15**.
BORCHARDT, PROF., *Berlin*, **2**.
BORCHARDT, E., 37, *Heinrichstrasse, Hanover*, **10**.
BRAUN, DR. O., *Berlin*, **12**.
BREITHAUPT, J. W., AND SON, *Cassel*, **3, 11, 15, 16, 17**.
BRENDEL, R., *Kurfürstendamm, Berlin*, **18**.
BRESLAU COMMITTEE FOR THE SCIENTIFIC APPARATUS EXHIBITION, LONDON, *Breslau*, **2, 3, 8, 11, 13, 14, 18**.
BRILL, PROF. DR. (Polytechnic School), *Munich*, **2**.
BROCKING, W., *Hamburg*, **3**.
BRUHNS, PROF. DR., *Leipzig*, **11**.
BÜCHLER, J. H., *Breslau*, **13**.
BUFF, PROF. DR., *Giessen*, **3, 4, 7, 10**
BUNGE, P., *Hamburg*, **3**.
CARL AND HOMANN, *Nuremberg*, **15**.

SPAIN.

SCIENCES, *Madrid*, **11**.
...AL MUSEUM, *Madrid*,

...L OBSERVATORY, *Ma-*

...E HORNOS, B. FEDE-
..., *Calle de San Andres*,
...

..., *Plaza de Santa Bar-*
...*id*, **16**.

COMISION DEL MAPA GEOLOGICO DE ESPAÑA, 23, *Calle de Isabel la Catolica, Madrid*, **15**.

GEOGRAPHICAL AND STATISTICAL INSTITUTE OF SPAIN, *Madrid*, **15**.

MINISTRY OF MARINE, *Madrid*, **15**.

QUIROGA, F., 8, *Union, Madrid*, **16**.

SAAVEDRA, E., 14, *Calle de San Joaquin, Madrid*.

SWITZERLAND.

..., H., 14, *Heumatt-*
...*ale*, **3**.
...UM, THE, *Basle*, **8**, **9**.
..., 45, *Boulevard des*
Geneva, **15**.
..., 15, *Rue St. Pierre*,
...**10**.
...ROF. D., 1, *Boulevard*
...*eva*, **3**, **4**, **5**, **6**, **10**, **12**.
...L., *Geneva*, **8**, **10**.
...OLLECTION, *Geneva*, **5**,

H., *Geneva*, **10**, **14**.
..., *Geneva*, **3**.
..., *Rue des Granger*,

...R. F. A., *Morges*, **14**.
...ATION FOR THE CON-
SCIENTIFIC INSTRU-
..., **2**, **3**, **4**, **5**, **7**, **8**,
5, **16**.
Zurich, **14**.
...HOFF, PROF. DR. E.,
Physical Science at
...*um, Basle*, **8**, **9**.

HERMANN, PROF. DR. L., *Physiological Laboratory, University of Zurich*, **7**, **10**.

LINDER, G., 29, *Gerbergasse, Basle*, **10**.

MOUSSON, PROF. A., *Zurich*, **5**, **7**.

PICTET (RAOUL) & Co., *Geneva*, **6**.

RAMBOZ AND SCHUCHARDT, *Geneva*, **10**.

RECORDON, PROF. E., 58, *Terrassière, Geneva*, **11**, **12**, **15**.

SARASIN, G., *Tour de Boleseart, Geneva*, **2**, **11**, **13**.

SCHMID, A., *Engineer, Zurich*, **3**.

SORET, L., *Geneva*, **7**, **8**, **13**, **14**.

SORET, PERROT, AND SARASIN (De la Rive Collection), *Geneva*, **5**, **7**, **10**.

STAPFF, DR. F. M., *Geological and Mining Engineer, St. Gothard Railway*, **1**.

WARTMANN, E., *Professor of Natural Philosophy, University of Geneva*, **8**, **10**.

WOLF, PROF. R., *Director of the Observatory, Zurich*, **14**.

CATALOGUE.

SECTION 1.—ARITHMETIC.

West Gallery, Ground Floor, Room G.

I.—SLIDE RULES.

1. **Slide Rule,** of boxwood, arranged by Mr. Dixon, Lowmoor Ironworks. *Aston & Mander.*

In addition to the lines of the ordinary slide rule this instrument contains :
Lines of common and hyperbolic logs and numbers.
Lines of sines, cosines, and numbers.
Lines of cubes and roots, direct.
A copy of Dixon's "Slide Rule Practice" is issued with each rule.

2. **Slide Rule,** of ivory, showing the actual and racing tonnage of yachts. *Aston & Mander.*

The length and breadth of beam being "set," as directed in the instructions, the tonnage of yachts of any size is shown as marked.

3. **Slide Rule,** of boxwood, adapted to brickwork measurement in all its branches. *Aston & Mander.*

In this adaptation of the rule to brickwork measurements, all the results are obtained by one setting, viz., length and height; while, immediately opposite, any thickness will be found ; the superficial area in square feet ; the contents in rods of reduced work, 1½ bricks, in cubic feet, in cubic yards, and the number of bricks required.

4. **Slide Rule,** of boxwood, adapted to timber measurement in all its branches, giving the superficial or cubic contents of round and unequal sided timber, St. Petersburg standard. *Aston & Mander.*

5. **Slide Rule,** of boxwood, with reversible slides, movable inverted lines, &c. *Aston & Mander.*

Uses explained in Hoare's "A. B. C. of Slide Rule Practice."

6. **Slide Rule,** of ivory, with reversible slides, movable inverted lines, &c. *Aston & Mander.*

Uses explained in Hoare's "A. B. C. of Slide Rule Practice."

7. Slide Rule, of ivory, adapted for use in iron and steel plate and sheet rolling mills. *Aston & Mander.*

This rule will show directly the precise net and waste weight of iron and steel plates, and sheets, of any size, shape, and thickness. It may be applied to all ordinary metals, and to find areas, cubic contents, liquid capacity, &c.

8. Slide Rule, of boxwood, adapted for sheet iron and steel manufacturers. The dimensions, thicknesses, and weights are given both in English and metrical standards. *Aston & Mander.*

The length of the sheet or plate (on the slide) being first set to the width, then immediately below any thickness (on the top lines) will be found (on the slide) the actual weight of the sheet either in pounds (avoirdupois) or kilogrammes.

9. Slide Rule, of ivory, adapted for use in iron and steel-bar rolling mills, showing instantly the precise net and waste weights for bars of any length, size, and form. *Aston & Mander.*

9a. Three Slide Rules. *Elliott Brothers.*

10. Estimator. A sliding rule, by which the volume of prismoidal bodies (embankments, ditches, cuttings, &c., occurring in the construction of railroads, canals, fortifications, &c.,) is calculated mechanically.

Dr. F. M. Stapff, Geological and Mining Engineer at the St. Gotthard Railway.

This instrument, invented by the exhibitor, is patented in Sweden and the United States of America.

11. Set of Gauging Instruments. *Dring and Fage.*

Head rod. For ascertaining the head diameter of a cask, and working out the contents.

Bung rod and slide. For finding the bung diameter and diagonal of a cask. The rod is divided into inches and tenths, with a line of imperial area and diagonal line; this last gives the approximate content without calculation, and is computed on the assumption that most casks are similar to one another in form, and therefore vary as the cubes of their like dimension.

Long callipers used for finding the internal length of a cask from head to head.

Cross calliper. Used for finding the external diameter of a cask.

Stave gauge. For finding the thickness of the stave in a cask.

11a. A Timber Rule, for finding the content of timber of any form, regular or irregular. The rule has eight gauge points or divisors for reducing dimensions in inches to contents in square feet. *Dring and Fage.*

11b. "Verie" or Excise Officer's Rule. *Dring and Fage.*

Verie is probably a corruption of "Vero," a revenue officer who made an alteration in the method of laying down some of the lines on the rule; previously to which they were called Everard's rules.

The lines on the rule are the A, B, C, D, MD, (or malt depth) 6x or variety lines, viz., 1st, 2nd, 3rd, 4th, Dr. Hutton's and Dr. Young's, and two ullage lines (segment standing and segment lying).

The A, B, C, and D lines are commonly called Gunter's lines (from Gunter the celebrated mathematician, who was the first to apply a logarithmic line for the instrument to the solution of arithmetical problems) of which the A, B, and C, are merely repetitions of each, and laid down to single radius, and the D to double radius.

The MD line is similar to the A, B, and C, but is a broken line of two radii, with the figures and divisions in an inverted order (reading from right to left), commencing at 2218·192 in the right-hand radius, and ending at the same point in the left-hand radius, 2218·192 being the number of inches in a bushel. By the method in which this line is arranged and used in conjunction with the A, B, and C lines the contents in bushels of rectangular and similar figures may be found at one operation.

The X or variety lines or lines of special gauge points (invented by Mr. Woolgar) for finding the mean diameter of a cask whatever its form; these lines commence at 18·789, the circular gauge point, and are extended according to each variety to which they may be applied.

The ullage lines are rules for finding the contents of a cask by comparison with a standard cask holding 100 gallons, a form nearest those frequently occurring in practice.

It cannot be ascertained by whom these lines were invented.

The fixed gauge points on the rule are those for the imperial gallon and bushel, both square and round.

These rules are principally used by excise officers and maltsters. So admirable is the arrangement, that nearly every problem to which the principle of the slide rule is applicable can be solved on one of these rules.

11c. Slide Rule, invented by Mr. Coulson, of Redan, used for setting out railway curves, finding the weights of materials from their specific gravities, breaking strains, &c.

Dring and Fage.

The applications of this rule are so varied that the author's description of them exceeds 400 octavo pages of closely printed matter.

12. Slide Rule, by M. Mabire.

Conservatoire des Arts et Métiers, Paris.

12a. Cylindrical Reckoning Rule. (This rule belongs to the Conservatoire des Arts et Métiers.)

M. Mannheim, Professor at the Polytechnic School, Paris.

13. Calculating Rules, 1 of 50 cm., 1 of 36 cm., 1 of 26 cm., as arranged by M. Mannheim.

M. Tavernier Gravet, Paris.

13a. Small Cylindrical Calculating Machine. Arranged by Herr Mannheim. *Conservatoire des Arts et Métiers, Paris.*

[redacted]

21. Calculating Machine, designed by Viscount Mahon, afterwards third Earl Stanhope (1753–1816), and constructed by James Bullock in 1775. Formerly belonging to Mr. C. Babbage, F.R.S.

Major-General Babbage.

22. Calculating Machine, designed by Viscount Mahon, afterwards third Earl Stanhope (1753–1816), and constructed by James Bullock in 1777. Formerly belonging to Mr. C. Babbage, F.R.S.

Major-General Babbage.

23. Babbage's Calculating Machine; or Difference Engine. *Exhibited by permission of the Board of Works.*

This machine was invented by the late Mr. Charles Babbage, F.R.S., who was born on the 26th December 1791, and died on the 18th October 1871.

Its construction was commenced in 1823 by authority, and at the cost of the Government, and was carried on for several years under Mr. Babbage's gratuitous supervision. The work was suspended in 1833, and after many delays, Mr. Babbage was informed in November 1842 that the Government regretted the necessity of abandoning the machine, alleging the expense of its completion as the ground for their decision.

At the time of its suspension about 17,000*l.* had been expended by Government upon its construction, and a large part of the machinery had been made. The small portion now exhibited was put together in 1833, prior to the suspension of the work, in order to show the action of the machinery.

The whole engine, when completed, was intended to have had 20 places of figures and 6 orders of differences.

This machine was expressly designed for the purpose of calculating and printing tables, and not to perform single arithmetical sums.

If a single article is wanted, it is not, generally speaking, worth while to construct a machine to make it; but, when large numbers are required, their production comes within the true province of machinery, and in this sense the Difference Engine is emphatically a machine for manufacturing tables.

The mode in which the Difference Engine calculates tables is, by the continual repetition of the simultaneous addition of several columns of figures to other columns, in the manner more particularly described below, and printing the result.

In the small portion put together, and now exhibited, the figure opposite the index on the lowest wheel visible, in all cases, represents units; the figure on the next wheel above, tens; that on the one above it, hundreds; the next thousands, and so on.

The right hand column of wheels shows the result of the calculation or the tabular number; for instance, series of squares, cubes, or logarithms, &c. appear upon it, according to the nature of the calculation the machine is making.

The next or central column represents the First Difference, and the left hand column the Second Difference. At the bottom of the central column is a figure wheel, covered, which can be used as a third difference, so as to enable this portion of the machine to calculate tables of which the Third Difference does not exceed 9. This will be better understood if this last wheel is supposed to represent the lowest wheel of a fourth column of figures standing beyond the left hand side of the machine, as it would be if it formed part of the complete machine.

This arrangement is effected by a movable platform, with axles, and gearing wheels upon them, which are used for adding from the third difference wheel

at the bottom of the central column to the second difference which is shown on the left hand column. The effects capable of being produced by this mechanism, when the gearing is altered, and the loose wheels belonging to it are put into gear with certain figure wheels, is explained in Babbage's Ninth Bridgewater Treatise, together with the new views which it opened up to him upon the subject of natural laws.

The three upper wheels of the left hand column are separated from the rest of the machine, and are employed in counting the natural numbers. In other words, they register the number of calculations made by the machine, and give the natural numbers corresponding with the respective terms of the table.

Four half turns of the handle, two backwards and two forwards, are required for each calculation, and the words "calculation complete" come round upon a wheel at the top of the central column to show when this is done. This wheel also shows, by the word "adjust," in what position of the handle the figure wheels may be freely moved by hand, in order to introduce different numbers or a different table.

24. Scales, of boxwood, to show cubes, squares, and roots, areas, diameters, circumferences, and decimal equivalents.

Aston & Mander.

The bevel edged set square is used to read the divisions, and dispenses with the need of voluminous tables.

25. Panometer, or Calculating Machine.

Edward Grohmann, Vienna.

By this extremely simple apparatus, various arithmetical computations can be performed with great readiness.

25a. Calculating Machine for Multiplication.

P. Nicholas Dadiane, St. Petersburg.

26. Calculating Machine, for performing complex arithmetical operations; invented by M. Thomas of Colmar.

Professor Hennessy, F.R.S.

26a. Calculating Machine for Adding, Subtracting, Multiplying, and Dividing.

Theodore Esersky, St. Petersburg.

26b. Small Calculating Machine, encased in a pocket-book.

Theodore Esersky, St. Petersburg.

26c. Ten Copies of Multiplication and Division Tables.

Theodore Esersky, St. Petersburg.

27. Wertheimber's Calculating Machine, applicable to wheel work. Patent, No. 9616—1843.

The Committee, Royal Museum, Peel Park, Salford

28. "Napier's Bones" or Rods (obsolete). Made about 1700.

Dring and Fage.

Invented by Baron Napier, the originator of logarithms, used for performing division and multiplication.

28a. Set of Napier's Bones. 16th century.

Lewis Evans, Hemel Hempsted.

29. Calculating Disc, size about 18 centimeters, with double divided circle; constructed on the system of Prof. Sonne, cf. No. **4002.** *Landsberg and Wolpers, Hanover.*

30. Calculating Disc, with index of logarithms.
Landsberg and Wolpers, Hanover.

31. Calculating Disc, pocket apparatus.
Landsberg and Wolpers, Hanover.

32. Calculating Circle, 0·08 meters in diameter, with single scale of brass. *Rudolf Weber, Aschaffenburg.*

33. Calculating Circle, 0·15 meters in diameter, with single square and cubic scale. *Rudolf Weber, Aschaffenburg.*

The circles are on account of their continuous scale more convenient and more accurate than straight slide rules. They are, therefore, peculiarly adapted as pocket instruments for practical purposes, and can be relied on to be as accurate as logarithms to four places.

34. Cubing Circle, 0·08 meters in diameter, for ascertaining the cubical contents of trees in forests.
Rudolf Weber, Aschaffenburg.

The cubing circle is to be noted as giving the index numbers for obtaining the cubical contents of *standing* (not felled) timber; these have been obtained from practical experiments carried out by the Government Department of Forests in Bavaria on more than 40,000 trunks of different kinds of trees. The circle may be relied on for great accuracy in forest valuation.

35. Calculating Instrument, invented by Sir S. Morland.
Bennet Woodcroft, F.R.S.

35a. Calculating Planisphere. *Royal College of Science.*

35b. McFarlane's Calculating Planisphere.
The Committee, Royal Museum, Peel Park, Salford.

36. Calculating Machine, designed by the Vicar Hahn of Echterdingen, in 1770-1776; constructed by his son, Court Mechanician in Stuttgart, in 1809; fourth specimen.
Her Highness the Duchess of Urach.

The machine which is exhibited is on exactly the same principle as that of the one now in general use which was invented by Thomas, the only difference being that in Thomas's machine the numbers are placed in straight lines, and in that of Hahn in a circle. It must have served as a model for the machine of Thomas. The machine is to the present day in perfect order, and works calculations up to numbers of 12 digits.

37. Logarithmic Calculation Apparatus, with *one* folding scale, five meters in length.
Prof. Gustav Hermann, Aix-la-Chapelle.

Calculation by means of this instrument is effected with the use of only one scale. The two revolving arms are used like a compass. When the logarithm

of a quotient $\frac{a}{b}$ has been fixed between the arms, the plate must be turned until the one arm is brought to a factor c, the product $\frac{a}{b}c$ will then be read on the other arm. This arrangement admits of the scale being made as long as may be necessary by breaking it into lengths, without rendering the instrument inconvenient. In the exhibited instrument ten circles are used, by which means the scale attains a length of five meters, and is accurate up to $\frac{1}{10000}$. In using the instrument care must be taken to mark the number of each scale circle, which can be fixed by small sliding buttons. The number of the circle on which the result is to be read is found by the same rules as the characteristic of a logarithm, on the supposition that the ten scale-circles form a graphic table of logarithms of all the natural numbers, the base of the system being $\sqrt[10]{10}$.

38. Arithmetical Disc, a very simple calculating machine, with accompanying description. *Prof. Prestel, Emden.*

39. Calculating Machine, of the last century.
The Royal Gewerbe Academy, Berlin (Director Prof. Reuleaux).

This calculating machine formed part of the legacy of Hofrath Beireis, the well-known physicist and chemist in the 18th century, and is very similar to the calculating machine, No. 36.

40. Tide Calculating Machine.
Sir William Thomson, F.R.S.

41. Pascal's Calculating Machine (1642).
Conservatoire des Arts et Métiers, Paris.

42. Petroff's Arithmetical Apparatus.
M. Petroff, Master at the School, Kalouga.

43. Arithmometer, with measuring apparatus, and the full size skeleton of the square metre and cubic metre, folding up by means of a hinge. *Frère Memoire Piron.*

44. Counters and Speed Indicators.
T. R. Harding and Son.

(a.) Counters with reciprocating motion, as applied to marine and stationary engines.

Counters with rotary motion, suitable for shafting, printing, and other machinery.

Small counters with rotary motion applicable to spinning machinery and various other purposes.

Speedometers or pocket counters for ascertaining the speed per minute of spindles or quick running machinery up to 10,000 revolutions per minute.

(b.) Counters actuated by pneumatic and electric apparatus at a distance from the motion to be indicated.

(c.) Speed indicators, showing by the height of a column of mercury the actual speed, at any moment, of engines and other machinery.

45. Model of Gas Meter Counting Machine.
Council of King's College, London.

46. Cavendish's Original Counting Machine.
Council of King's College, London.

47. "The Motometer," a machine to indicate the number of revolutions made per minute, or other portion of time, by a steam engine or revolving shaft or other body having intermittent motion, so that by simple inspection of a dial the rate of speed may be seen. *H. Faija.*

This instrument is constructed so as to indicate by a positive motion direct from the engine or other moving body to which it is attached, and is of purely mechanical construction independent of all centrifugal and other forces of an indirect nature. The indication is consequently absolute and not comparative.

The instrument is made in four different forms according to requirements; for instance,—

No. 1 is intended for slow motions, as in pumping engines, &c., where each separate revolution is indicated.

No. 2. For all ordinary marine and stationary engines with speed varying from 20 to 100 revolutions per minute, in which case the speed is indicated at every tenth revolution.

No. 3. To indicate extremely high speeds, such as locomotives, &c.

No. 4. To indicate at the termination of each minute the exact number of revolutions made during that minute.

The machine exhibited is No. 2, being the form adapted to most general purposes.

III.—MISCELLANEOUS.

48. Apparatus for the Statistical Treatment of large numbers of Seeds, &c., to sort them rapidly into classes differing by regular gradations of magnitude, with the view of testing how far the relative numbers in the several classes accord with the results of the Law of Error or Dispersion.
Francis Galton, F.R.S.

It consists of a box, with bars parallel to one another, and having a bevelled edge, fixed horizontally across its top. There is also a frame of other bars, held together like those in a gridiron, that lie on the top of the box between these. Consequently, when the frame is pulled forwards as far as it can go, each of its bars closes along its whole length against one of the fixed bars, and when it is pushed gently back the framework bars separate simultaneously and equally from the fixed bars, and any objects that may have been laid in the bevel between their edges, and are small enough, will drop through. The framework is moved by a screw turned by a ratchet wheel, which is itself moved by the to-and-fro action of a handle between stops, one of which is adjustable at pleasure. Hence, every time the handle is worked, the space between the bars is widened by a definite space, and all the seeds, &c., whose diameter is greater than the original and less than the final space, will drop

hrough. A tray, divided into compartments, slides beneath the box; it is ushed forward through the space of one compartment before giving a fresh tovement to the handle, and thus the seeds become sorted into the different ompartments. (This instrument was used to illustrate a lecture before the oyal Institution on Friday evening, February 27, 1874.)

49. Apparatus affording Physical Illustration of the ction of the Law of Error or of Dispersion.

Francis Galton, F.R.S.

Shot are caused to run through a narrow opening among pins fixed in the ice of an inclined plane, like teeth in a harrow, so that each time a shot passes etween any two pins it is compelled to roll against another pin in the row nmediately below, to one side or other of which it must pass, and, as the rangement is strictly symmetrical, there is an equal chance of either event. he effect of subjecting each shot to this succession of alternative courses is, disperse the stream of shot during its downward course under conditions lentical with those supposed by the hypothesis on which the law of error is ommonly founded. Consequently, when the shot have reached the bottom of he tray, where long narrow compartments are arranged to receive them, the general outline of the mass of shot there collected is always found to assimilate to the well-known bell-shaped curve, by which the law of error or of dispersion is mathematically expressed. (This arrangement was devised, by the exhibitor, to illustrate a lecture before the Royal Institution on Friday evening, February 27, 1874.)

50. Practical Approximation to the value of the circumference in terms of the diameter, by means of a right angled triangle having one acute angle $=27° \; 35' \; 49{\cdot}636''$.

Edward Bing, Riga.

For the purpose of effecting this object, as well as for answering kindred questions, use is made of a triangle, specimens of which are here exhibited, and of which one angle is a right angle and another is defined by an equation.

SECTION 2.—GEOMETRY.

WEST GALLERY, GROUND FLOOR, ROOM G.

I.—INSTRUMENTS USED IN GEOMETRICAL DRAWING.

52. Pantograph.
Royal School of Industry, Cassel. (Dr. W. Narten.)

This pantograph was made for the geodetic collection of the school, in the year 1866, by Messrs. Breithaupt and Son, Cassel. It is used for enlarging and diminishing maps and plans. Peculiar to this construction is the movement of all the arms in points, by which means friction is as far as possible avoided. The employment of tubes instead of the usual rectangular bars is also to be recommended, as by this means all bending, which creates errors in the use of the instrument, is avoided; besides which, the weight of the whole is considerably decreased, thus also lessening friction in the movement of the points.

The peculiar construction of this pantograph was invented and carried out by Messrs. Breithaupt and Son, and the instrument possesses in consequence great accuracy and facility of use.

53. Pantograph. *Renaud Tachet, Paris.*

54. Pantograph, with free hanging arms of new construction.
Albert Ott and Gottlieb Coradi, Kempten.

By means of this instrument figures on a reduced or an enlarged scale can be transferred either on paper, stone, or metal.

These pantographs differ in their construction from other similar instruments by not resting on friction-rollers, but are freely suspended by means of elastic metal wires from cast-iron *crane*-like frames; thus only a small portion of each instrument rests on the table. The advantages of this construction are these: easy and secure management of the instrument; any ordinary table may be used of a size sufficient to afford room for the stands, the original, and copy; the accuracy of the graphic representation is greater at less cost.

The guidance of the instrument is so easy and so accurate that with a little practice every outline can be graphically reproduced. Drawings, likewise, can be transferred on substances measuring a certain height, such as lithographic stones, it being only necessary to place frame and original correspondingly higher. In producing enlarged copies both the guiding peg and the drawing pencil must be exchanged, and the releasing cord fastened accordingly. The guidance, in making enlarged copies, is also performed with the handle of the tracing pencil with the same accuracy as when making reduced copies.

54a. Horizontal Pantograph, traversing a surface of 36 inches in length by 20 inches in width. Reduction from $\frac{1}{2}$ to $\frac{1}{12}$.
L. Oertling.

54b. **Pantograph,** large model, with double scale and reverse ion, belonging to the Indian service. Four of these large inments are now in use. *M. Adrian Gavard, Paris.*

54c. **Frame,** containing the figures of pantographs and pantoygraphs drawn with the above instrument.

55. **A Large Collection of Mathematical Instruments Geometrical** and **Fortification Drawing,** as well as for **tillery purposes.** Property of His Highness the Prince ess, Fürstenstein. *Committee of Breslau.*

'his ancient collection, dating from the commencement of the last century, emarkable for the excellent workmanship and good state of preservation the instruments.

t *contains* 19 compasses and 11 accessory parts, 28 rules and scales, two of same with two keys for fortification drawing, eight triangles and set ares, 10 protractors, two pantographs, and 52 other instruments. In all, pieces.

56. **Case of Mathematical Instruments.**
Renaud Tachet, Paris.

57. **Proportional Compasses.** *Renaud Tachet, Paris.*

58. **T-squares, Set Squares, and Curves.**
Renaud Tachet, Paris.

59. **Diagonal Scale.**
Geneva Association for Constructing Scientific Instruments.

60. **Scales** made of **Mica,** for use in geometrical drawing (see Nos. **275, 879, 2591, 3468,** &c.).
Max. Raphael, Breslau.

61. **Perspective Apparatus** invented by James Watt.
Bennet Woodcroft, F.R.S.

62. **Complete Set of Mathematical Instruments,** with all the modern improvements; as used by professional draughtsmen, &c.; illustrated by diagrams of work performed.
Wm. Ford Stanley.

62a. **Magazine Case of Drawing Instruments.**
Henry Porter.

64. **A Case of Mathematical Instruments,** probably Dutch, made at the beginning of the 18th century.
Lewis Evans.

65. **Two Cases of Drawing Instruments.** *Mark Eames.*

66. Beam Compass, T-squares, Set Squares, and Curves. *Bock and Handrick, Dresden.*

67. Models of Mathematical Instruments. The orthocompass and the addition compass. *Prof. L. Zmurko, Lemberg.*

The first of these instruments is constructed so that the points of the compass are always parallel to each other, and perpendicular to the surface of the paper. The second is a compass which can be used also as a protractor, as it contains an apparatus which indicates the amount of opening between the arms.

69a. Photographs of Mathematical Instruments. *Otto Fennel, Cassel.*

69d. Révoil Tele-iconograph, altered for perspective drawings enlarged to 20 times on a horizontal plane-table. *M. Georges Sarasin, Geneva.*

The instrument consists of a telescope, adapted to a Wollaston *camera lucida*, and fixed on a stand arranged so as to make it a mathematical or scientific instrument. In order to facilitate the exact grouping of the partial perspectives in accordance with a general cylindrical perspective, and capable of being developed, and in order to permit of drawing while the telescope is inclined at great angles, the following additions have been made to the Révoil model:—1st. A tightening ring with an adjusting screw on the thread of the screw which fixes the prism on to the eye-piece. 2d. A web of six threads crossed at right angles in the focus of the object glass. 3d. A spirit level on the telescope stand. 4th. A socket and rack joint, permitting of the height of the instrument being adjusted above the drawing. 5th. A graduated scale with vernier, giving a reading to five minutes on the horizontal limb. 6th. A method of attaching the instrument to its stand, so as to be at the same time firm and easy to work.

69e. Set of Instruments for Geometrical Drawing. *See* Appendix, page 915. *E. G. Richter and Co., Chemnitz.*

II.—INSTRUMENTS FOR TRACING SPECIAL CURVES.

70. Conograph. An instrument by which the various conic sections may be drawn.

a. Ellipso-Parabolograph.
b. Hyperbolograph.

Dr. Lawrence Zmurko, Lemberg.

This instrument consists of two movements independent of, and perpendicular to, each other; the first of these is set in action by turning a disc, the second by means of a spring. These movements are so contrived that the extent of the second motion shall be such a function of that of the first as to cause a conic section to be described.

71. Cycloidograph. An instrument for tracing cycloids. *Dr. Lawrence Zmurko, Lemberg.*

71a. Instrument for tracing with accuracy ellipses and spirals up to 25 centimetres. *M. Adrian Gavard, Paris.*

72. Instrument for drawing **Conic Sections.**
Edward Uhlenhuth, Anclam, Pommerania.

This instrument, which was invented by the exhibitor, shows in the first place the formation of the parabola. By altering the arrangement according to the instructions given in the sketches on the drawing board, the construction of the ellipse and hyperbola easily follows.

73. Elliptic Compass. *Renaud-Tacket, Paris.*

74. Colonel Peaucellier's Compound Compass.
Conservatoire des Arts et Métiers, Paris.

75. Compound Geometric Chuck, producing the kinematic retrogressive parabola, by continuous motion; either on a moving plane by a fixed point, or on a fixed plane by a moving point. *Henry Perigal, F.R.A.S.*

76. Machine for **Compounding two Simple Harmonic Curves.**
Invented and constructed by A. E. Donkin, M.A., Rugby School.

A strip of paper is wound round the cylinder; the little glass pen moving backwards and forwards on it draws one curve, a similar motion of the cylinder the other. Since both move at once the curves are combined, and the result rendered visible to the eye by the revolution of the cylinder.

A. Eccentric for giving simple harmonic motion to pen.
B. " " " cylinder C.
D. } wheels for determining relative numbers of vibrations of pen and
E. } cylinder.
F. Wheel for transmitting slow motion to pinion G which turns the cylinder.
H. Idle wheel.
I. Change wheels to supply different ratios of vibration of pen and cylinder.

76c. Spherical Rules and Squares for Spherical Drawing. *Dumoulin Froment, Paris.*

76a. Working Model of a Trace-Computer, designed by the Exhibitor, for the use of the Meteorological Office.
Francis Galton, F.R.S.

Given two ordinates having the same abscissa, the instrument, of which this is a working model, pricks out a third ordinate that shall be some desired function of the other two. The original instrument was contrived for the use of the Meteorological Office, where it is employed to derive a trace for humidity from the traces of the dry and wet bulb thermometers. It consists of a hori-

zontal slab, whose upper surface has been shaped, as hereafter described, in accordance with numerical tables, calculated from the desired function, the height of its surface at each point being the tabular value corresponding to the two entries severally represented by the distance of that point from the front and from one side of the slab. The plate that carries the two traces is placed horizontally on a frame that travels in front of the slab. Two slides move at right angles to this plate, and have microscopes attached to them, that traverse the paper along ordinates having the same abscissa. One of these slides is rigidly connected with a frame on which the slab is able to move from side to side; when this slide is pushed, the frame and the slab together are pushed with it. The other slide gives a sidelong movement of the slab on the frame. Thus the particular point of the slab that corresponds to the values of the two ordinates is brought vertically below a descending rod, and this is caused to drop gently on the surface of the slab by touching a treadle. The vertical space through which the rod descends is consequently the function required. The rod carries a horizontal pricker, with which it makes a dot on a plate held vertically in the same stage that carries the plate on which the two traces are drawn. The slabs can readily be fashioned by instrument-makers who possess the necessary apparatus according to any required tables. They are drilled to the requisite depth at various points, and are afterwards smoothed down.

76b. Rule, with joint, which serves to curve an elastic plate into an arc of the circle, of any radius.

Professor Tchebichef, University of St. Petersburg.

III.—MODELS OF FIGURES IN SPACE.

Collection of Models of Ruled Surfaces, constructed by M. Fabre De Lagrange, in 1872, for the South Kensington Museum.

This collection illustrates the principal types of the class of surfaces which can be traced out in space by the motion of a straight line.

These surfaces, on account of the facility with which they can be constructed and represented, and of the ease with which their intersections can be determined, are of more consequence than any others in the geometry of the Industrial Arts. It is only in small work, which can be put into the lathe, that the class of surfaces of revolution approaches them in respect of general utility. The most important surfaces of all, the plane, the right cylinder, the right cone, and the common screw, belong to both classes.

The representation of the surfaces by means of silk threads is of course only approximate; an approximation of the same character as the representation of a curve by a dotted or chain line, or by a series of right lines touching the actual curve.

The models are constructed with especial reference to the possibility of changing their shape, by moving some of the supports of the strings, by altering the lengths or positions of certain parts, or by converting upright forms into oblique. This possibility of *deformation*, as the process is technically called, greatly enhances the value of the models, by allowing them to represent a much greater variety of surfaces than if they were fixed. They are, however, too delicate to be much pulled about, and, unless they are very cautiously

lled, the strings are apt to become entangled or break. They should never used except by a person who understands them, and they should not be ed without some good reason.

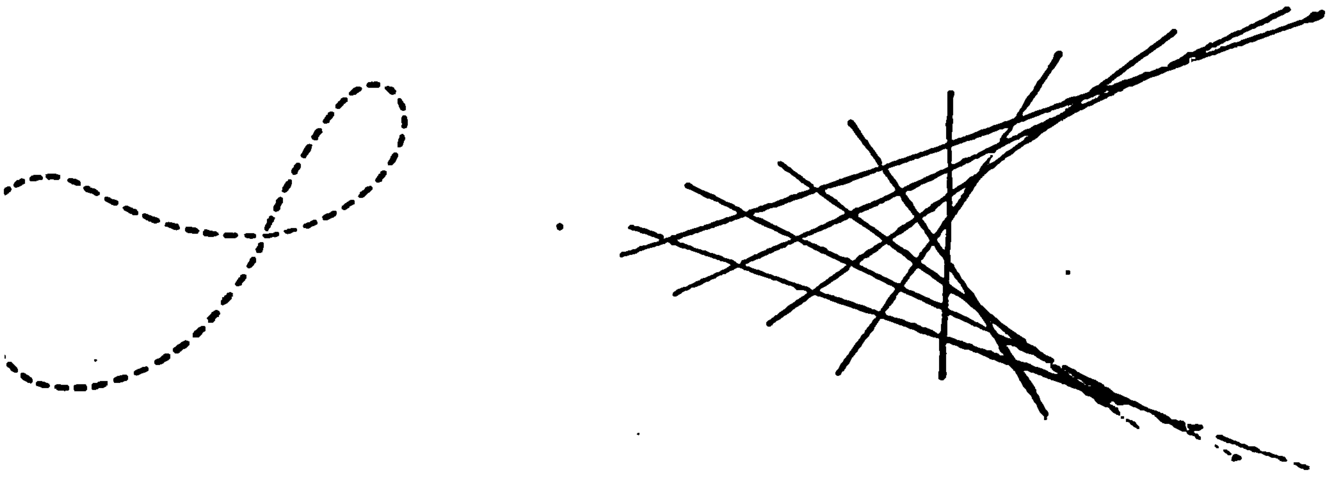


FIG. 1. FIG. 2.

Fig. 1 is an example of the first, and Fig. 2 of the second. In both cases, curve, although not actually drawn, is indicated with sufficient approximation for most practical purposes. Models Nos. 10 and 30 also afford illustrations of the principle exhibited in Fig. 2.

Geometrical drawings of most of the surfaces represented by these models contained in BRADLEY'S *Practical Geometry* (2 vols., oblong folio, published by Chapman and Hall). Many of them will also be found in the French treatises on practical and descriptive geometry, such as LEROY, ...MAR, LEFEBURE DE FOURCY, DE LA GOURNERIE, and in their treatises *Stereotomy* and *Stone-cutting* (*coupe des pierres*). Many of them are also ...en in SONNET'S *Dictionnaire des Mathématiques Appliquées*. A catalogue this collection of models, with an appendix containing an account of the plication of analysis to their investigation and classification, was prepared the South Kensington Museum in 1872, by Mr. C. W. Merrifield, F.R.S. ...e following descriptions are extracted from this catalogue :—

77. Hyperbolic Paraboloid generated by a single system right lines.

Two bars, each pierced with holes, equally spaced. One bar is fixed, other swings round an axis, which, moreover, can be inclined at different gles to the fixed bar.

When the bars are parallel the strings indicate a plane. When they are clined to one another, but still in the same plane, the strings still indicate a ...ne; but when the bars are not in the same plane, the surface is the hyperbolic paraboloid.

The surface is sometimes called the *twisted plane*. But it must not be posed that it can be made by bending a plane. On the contrary, when surface is twisted, no two of the strings lie in the same plane, and, therefore, no part of the surface is plane. It can neither be flattened nor made ...m a plane, without stretching or contraction.

The hyperbolic paraboloid is the natural surface proper for a ploughshare.

78. Hyperbolic Paraboloid.

Two bars, pierced with holes at equal distances, the holes being connected two different systems of strings. The surface, as well as the arrangement, very nearly the same as in No. 1, only that there are two paraboloids instead of one. As the movable bar swings round, the paraboloid opens out while the other closes up. If the bars are swung so as to be in the same

plane, one system of strings describes a plane by parallel lines, and the other by lines radiating from a point. If one bar is now turned so as to be end for end, we still get a plane, the set of parallel lines now passing through a point, while the set which previously passed through a point has now become parallel.

The pair of paraboloids intersect in three right lines. There is also a fourth intersection on the "line at infinity."

79. Hyperbolic Paraboloid.

Two bars equally spaced; each turns on an arm perpendicular to itself, and one arm swings on a pillar. These arms can be ranged in one plane, and also turned end for end.

80. Hyperbolic Paraboloid generated by two systems of right lines.

A skew quadrilateral with four equal sides, each pierced with the same number of holes, equally spaced. The model exhibits the double generation of the surface. The plane containing two of the sides turns about hinges connecting it with the plane of the other two sides. By closing or opening this hinge the paraboloid opens out or closes. When completely open, it forms a plane divided into *diamonds*. When completely closed it again forms a plane, but the division is no longer uniform. The strings then become tangents to a plane parabola.

81. Hyperbolic Paraboloid.

A skew quadrilateral turning upon four hinges with parallel axes or pins.

The difference between this and the last is not in the kind of surface or mode of generation, but in the manner of *deforming* the surface. In No. 4 the lengths of the strings alter; while in this model they remain unaltered. Moreover, although the surface flattens in two ways, yet in both ways the strings become tangents to a plane parabola instead of parallel.

This model is well adapted for showing the leading sections of the solid. All sections parallel to the pins of the hinges are plane parabolas, which degenerate into right lines when taken also parallel to the brass bars. Any other sections, whether perpendicular to the hinges or inclined to them, give hyperbolas, which degenerate into a pair of right lines when the plane of section is a tangent to the surface.

It may be worth while to remark that there is nothing absurd in the tangent plane to a surface cutting that surface, as a student unaccustomed to those subjects might at first think. On the contrary, when a surface is bent one way in one direction, and the other way in the opposite direction, the tangent plane *must* cut it. In this case, the plane passing through any two intersecting strings is a tangent plane, and evidently cuts the surface along each string.

If we imagine two planes parallel to the hinge pins, and each bisecting a pair of opposite bars, we obtain the *asymptotic planes* of the paraboloid, each of which is the assemblage of the asymptotic lines of the hyperbolas parallel to the principal hyperbolic section. Their being asymptotic has reference to these hyperbolas, and not to the parabolic character of the surface.

82. Hyperbolic Paraboloid.

A skew quadrilateral, with its opposite sides equal in length, and pierced with holes at equal distances.

Nearly similar to No. 5, but differently mounted, and with the sides of different lengths, the alternate sides only being equal. It is virtually a slightly different aspect of the same surface as No. 5.

83. Hyperbolic Paraboloid.

A skew quadrilateral, with all its sides equal, and pierced holes at equal distances.

As far as the curved surface is concerned, the same as No. 5. But the hinges are altered in direction, and the model shows plans and elevations of the right line generators of the surface. The rings also show parabolic sections of the surface.

In consequence of the alteration in the direction of the hinges, the spacing of the inclined bars, although equidistant, is at a different pitch from that of the horizontal bars.

84. Hyperbolic Paraboloid.

A skew quadrilateral, with all its sides equal, and pierced with holes at equal distances. It shows the plans and elevations of the right line generators. The rings show the parabolas of the *principal sections*.

No. 7 represents one quarter of what is shown in No. 8. The upper corners of Nos. 7 and 8 correspond; but the lower corner of No. 7 corresponds with the middle ring of No. 8.

85. Hyperbolic Paraboloid.

A skew quadrilateral, with all its sides unequal. The surface is the same as Nos. 7 and 8, but the proportions and the portion of the surface chosen for representation are different. The quadrilateral base being irregular, the strings alter in length as the surface is deformed by closing the hinges.

86. Hyperbolic Paraboloid.

Skew quadrilateral, pivoting on a single hinge. Intended to show the construction of the parabola connecting two roads which meet obliquely. This construction is used by engineers in laying out roads.

87. Hyperboloid of one Sheet.

Two rings or circles, in parallel planes, are pierced with equally spaced holes. In a certain position the threads give, 1st, a cylinder; and 2ndly, a cone.

The upper ring turns round a pin at its centre. In turning it, the cylinder closes in and the cone opens out, each altering into a hyperboloid of one sheet. We can go on turning the ring until these coincide in one hyperboloid, of which we thus get both systems of generating lines.

If the rings are set on a slope the hyperboloid is elliptic. If the rings are horizontal the hyperboloid is one of revolution.

Sloping one ring, so as not to be parallel with the other, gives rise to some curious ruled surfaces, but these are not in general hyperboloids.

88. Hyperboloid of one Sheet.

Two rings of different radius, in parallel planes, are divided into the same number of equal parts. The smaller and upper ring turns round a pin at its centre. In a particular position of the rings, the threads give two cones. Turning the ring transforms each of the cones into a hyperboloid, and when the two hyperboloids coincide, we get the two systems of right line generators.

The same stand also has a model of a hyperboloid with only one set of strings. By turning the upper ring either way it deforms into a cone; in the one case with its vertex between the rings, and in the other with its vertex at a considerable height above the rings.

Both these can have their upper rings moved along the top bar so as to incline the surfaces. We still get cones and hyperboloids, but it is only

when the rings are horizontal, and centre to centre, that we get surfaces of revolution.

89. Hyperboloid of one Sheet, with its asymptotic cone.

90. Hyperboloid of one Sheet, with its asymptotic cone.

The tangent plane to the cone is also drawn. It meets the hyperboloid in two parallel right lines.

One of these right lines is the line of contact of a hyperbolic paraboloid with the hyperboloid, and the tangent plane is one of the director planes of the paraboloid, both systems of generating lines of which are exhibited.

91. Hyperboloid of one Sheet.

A slight variation from No. 14. The paraboloid only shows one system of right line generators, and the tangent plane is made by parallel instead of radiating lines.

92. Hyperboloid of one Sheet, and its tangent paraboloid.

This shows the transformation of a cylinder and its tangent plane into a hyperboloid and its tangent paraboloid.

93. Conoid, with its director plane. The director curve is a plane curve.

By shifting the position of the brasses the conoids deform into different conoids or other allied surfaces.

94. Conoid, with a director cone. The director curve is of double curvature.

By shifting the position of the brasses the conoids deform into different conoids or other allied surfaces.

95. Conoid, showing both sheets of the surface.

By shifting the position of the brasses the conoids deform into different conoids or other allied surfaces.

96. Conoids. Model showing the transformation of a cylinder into a conoid and back again. Also model showing the transformation of a cone into a conoid and back again. It is to be noticed that the head lines of the two conoids, that is to say, the right line in which the two sheets of each conoid meet, are perpendicular to one another.

The transformation is effected by making the upper semicircle turn through two right angles.

97. Conoids.

Intersection of two equal conoids having a common director plane. The horizontal intersection is a plane ellipse.

98. Conoid, in contact with a hyperbolic paraboloid.

99. Conoids. Two equal circles in parallel planes, divided equidistantly, are connected by threads, so as to form four surfaces.

A cylinder.	A conoid.
A cone.	A second conoid.

The director planes, as well as the head lines, of these conoids are at right angles to one another.

100. Conoids.

Two equal circles in parallel planes are connected by threads so as to form four surfaces.

A cylinder.
A cone.
A conoid.
A second conoid, with its director plane and line at right angles to those of the former.

Same arrangement as No. 23, except that the lower ring is replaced by a plane of section a little higher up. The section gives,—

For the cone, a circle smaller than the upper ring.
For the cylinder, a circle of the same size as the upper ring.
For the conoids, two ellipses turned crosswise.

101. Model exhibiting the simultaneous transformation of a conoid into a cylinder, a cylinder into a conoid, the paraboloid touching the conoid into the tangent plane of a cylinder, and the tangent plane of a cylinder into the tangent paraboloid of a conoid, and reciprocally.

The changes may be arranged as follows :—

From.	Into.
Conoid.	Cylinder.
Tangent paraboloid.	Tangent plane.
Cylinder.	Conoid.
Tangent plane.	Tangent paraboloid.

These changes are all effected simultaneously by one movement, which can be reversed.

102. Model exhibiting the transformation, first, of a conoid into a cylinder; second, of the tangent paraboloid of the conoid into the tangent plane of the cylinder.

103. French Skew Arch (*biais passé*).

The inner drum, of yellow thread, represents this surface. It is a skew surface, with a right line director; and its faces, the planes of the two semicircles, are usually parallel, although the model permits them to be placed obliquely to one another. The horizontal line joining the centres of the two large semicircles is the right line director.

The construction for any one of the generating lines is as follows :—Draw a plane through the right line director at any selected obliquity. It will, of course, give the radii of the outside circles, and the line joining the points at which it cuts the inside semicircles will be a generator of the surface. This line will evidently pass through the director line, because it is in the same plane with it.

The stone or brickwork, the sides of the voussoirs, will be given by the auxiliary plane in question. When the openings are parallel the voussoir joints are therefore plane, and the simplicity thus gained is the chief reason for adopting this form of skew arch. It is usual to take the right line direct or perpendicular to the openings, and symmetrical to them, that is to say, passing through the middle point of the parallelogram of the springing plane.

When the openings are not parallel the voussoir joints shown by the model are deformed into hyberbolic paraboloids. This deformation is, however, very slight, and in practical work would be avoided altogether by adhering to the principle of drawing a plane through the director line.

The opening of the voussoirs is usually determined by dividing the outer semicircle into equal parts.

This form of arch is inconvenient when the obliquity and the length of the barrel are excessive, for the generators are not generating lines of the cylinder containing the opening semicircles, but chords of it, and, therefore, at the middle, falling considerably inside it. The arch, therefore, droops in the middle, and this would be ugly and inconvenient if the proportions were excessive.

104. Staircase Vault for a square wall (*vis St. Gilles carrée*).

105. Staircase Vault. Model for exhibiting some properties of this ruled surface, by showing how it is obtained from the deformation of a cylinder (*douelle de la vis St. Gilles carrée*).

106. Cylinder with Helix and developable Helixoid.

The helix is simply a screw thread. The developable helixoid, shown by the purple threads, is the surface swept out by the right line tangents of the helix. If we consider that each gore can be turned a very little bit about the thread which separates it from the next gore, we see that the surface can be flattened out or developed into a plane, without any crumpling. This happens because every two consecutive generating lines meet one another on the helix. That is why its surface is called developable. Its section by a horizontal plane is the involute of the circle.

The model allows the pitch of the helix to be shortened by lowering the upper plate, and the cylinder can also be inclined. When oblique, however, the curve which replaces the helix is not such a screw thread as can be turned in the lathe.

107. Skew Helixoid.

This surface is described by a right line, which always passes through the axis of a cylinder, and makes a constant angle with that axis. It also passes through a helix or screw thread traced on the cylinder. The model only shows the surface, not the cylinder. The section by a horizontal plane is the spiral of Archimedes. It is the surface of what is known as the screw with a triangular thread.

This is not the commonest form of the skew helixoid; that is best seen on the underside of a screw staircase, or on the driving face of a common screw propeller. In these, two generating lines are at right angles to the axis.

The surface may also be considered as generated by a line which makes a constant angle with a given fixed line, and moves up that line, and at the same time turns round it, at uniform rates.

108. Skew Surface with its tangent paraboloid, capable of transformation into another skew surface while the paraboloid deforms into a plane.

intersection, but the plans of the intersection and of the generating lines.

121. Helix or Screw-thread.

Model showing the transformation of the right line generators of a right cylinder into screw threads of various pitch or obliquity.

The pitch of a screw is the distance between two successive turns, measured in a direction parallel to the axis. When this distance is small, the screw is said to have a fine pitch; when great, a coarse pitch or high pitch.

Collection of Models contributed by the London Mathematical Society.

123. Plücker's Models (14) of certain quartic surfaces, representing the equatorial form of complex surfaces.

London Mathematical Society.

At the meeting of the British Association at Nottingham, in 1866, Prof. Plücker read a paper on "Complexes of the Second Order." On this occasion he showed a series of models constructed by Epkens, of Bonn, of which the above are copies made for Dr. Hirst, and presented to the London Mathematical Society.

The following is Prof. Cayley's description of the models, extracted from Nos. 37 and 38 of the Mathematical Society's Proceedings, vol. iii., pp. 281–285, supplemented by a description of models A, B, C, D, E, F, drawn up by Prof. Henrici.

The Society possesses a series of 14 wooden models of surfaces, constructed under the direction of the late Prof. Plücker, in illustration of the theory developed in his posthumous work "Neue Geometrie des Raumes gegründet "auf die Betrachtung der geraden Linie als Raum-elemente," Leipzig, 1869. These, all of them, represent, I believe, equatorial surfaces, viz., eight represent cases of the 78 forms of equatorial surfaces, "deren Breiten-Curven "eine feste Axenrichtung besitzen," vol. ii. pp. 352–363; the remaining models, A, B, C, D, E, F, I have not completely identified. I propose to go into the theory only so far as is required for the explanation of the models.

In a "complex," or triply infinite system of lines, there is, in any plane whatever, a singly infinite system of lines enveloping a curve; and if we attend only to the curves the planes of which pass through a given fixed line, the locus of these curves is a "complex surface." Similarly, there is through any point whatever a single infinite series of lines generating a cone; and if we attend only to the cones which have their vertices in the given fixed line, then the envelope of these cones is the same complex surface. In the case considered of a complex of the second degree, the curves and cones are, each of them, of the second order; the fixed line is a double line on the surface, so that (attending to the first mode of generation) the complete section by any plane through the fixed line is made up of this line twice, and of a conic. The surface is thus of the order 4; it is also of the class 4; the surface has, in fact, the nodal line, and also 8 nodes (conical points), and we have thus a reduction = 32 in the class of the surface.

In the particular case where the nodal line is at infinity, the complex rface becomes an equatorial surface; viz. (attending to the first mode of eneration), we have here a series of parallel planes each containing a conic, id the locus of these conics is the equatorial surface.

It is convenient to remark that, taking a, b, h, to be homogeneous functions (x, w) of the order 2; f, g, of the order 1; and c of the order 0 (a constant); ien the equation of a complex surface is—

$$\begin{vmatrix} & y & z & 1 \\ y & a & h & g \\ z & h & b & f \\ 1 & g & f & c \end{vmatrix} = 0;$$

nd that, writing $w=1$, or considering a, h, b; f, g; c, as functions of x of ie orders 2, 1, 0 respectively, we have an equatorial surface.

A particular form of equatorial surface is thus, $bcy^2+caz^2+ab=0$, or iking $c=1$, this is $by^2+az^2+ab=0$, where a, b, are quadric functions of x.

The surface is still, in general, of the fourth order; it may, however, egenerate into a cubic surface, or even into a quadric surface; the last case , however, excluded from the enumeration. The section by any plane arallel to that of yz is a conic; the section by the plane $y=0$ is made up of ie pair of lines $a=0$, and of the conic $z^2+b=0$; that by the plane $z=0$ is iade up of the pair of lines $b=0$, and of the conic $y^2+a=0$; the last-menoned planes may be called the principal planes, and the conics contained in iem principal conics. The surface is thus the locus of a variable conic, the lane of which is parallel to that of yz, and which has for its vertices the itersections of its plane with the two principal conics respectively. And we ave thus the particular equatorial surfaces considered by Plücker, vol. ii. p. 346–363 (as already mentioned), under the form

$$\frac{y^2}{Ex^2+2Ux+C}+\frac{z^2}{Fx^2-2Rx+B}+1=0$$

nd of which he enumerates 78 kinds, viz.: these are—

1 to 17. Principal conics, each proper.
18 to 29. One of them a line-pair.
30 to 32. Each a line-pair.
33 to 39. Principal conics, each proper, but having a common point.
40 to 43. One of them a line-pair, its centre on the other principal conic.
44 to 61. One principal conic, a parabola.
62 to 73. One principal conic, a pair of parallel lines.
74 to 76. Principal conics, each a parabola.
77 and 78. Principal conics, one of them a parabola, the other a pair of parallel lines.

Model 2. The form of the equation is here,—

$$\frac{y^2}{l^2[(x-\alpha)^2+\beta^2]}-\frac{z^2}{l'^2[(x-\alpha')^2+\beta'^2]}=1$$

viz., the principal conics are one of them a hyperbola, the other imaginary; hence the generating conic has always two, and only two, real vertices, viz., it is always a hyperbola. There are no real lines.

Model 3. The form of the equation is—

$$\frac{y^2}{l^2[(x-\alpha)^2+\beta^2]}+\frac{z^2}{l'^2[(x-\alpha')^2+\beta'^2]}=1;$$

viz., the principal conics are each of them a hyperbola; the generating conic has four real vertices, viz., it is always an ellipse. There are no real lines.

Model 4. The form of the equation is—

$$\frac{y^2}{l^2(x-\gamma)(x-\delta)}+\frac{z^2}{l'^2[(x-\alpha')^2+\beta'^2]}+1=0.$$

The principal conics are one of them an ellipse, the other imaginary; for values of x between γ and δ, the variable conic has two real vertices, or it is a hyperbola; for any other values it is imaginary, so that the surface lies wholly between the planes $x=\gamma$, $x=\delta$. The surface contains the real lines $y=0$, $x=\gamma$, and $y=0$, $x=\delta$.

Model 9. The form of the equation is—

$$\frac{y^2}{l^2(x-\gamma)(x-\delta)}+\frac{z^2}{l'^2(x-\gamma')(x-\delta')}+1=0$$

where, say the values γ, δ, lie between the values γ', δ', the principal conics are each of them an ellipse, the vertices (on the axis or line $y=0$, $z=0$) of the one ellipse lying between those of the other ellipse. The variable conic for values of x between γ and δ has four real vertices, or it is an ellipse; for values beyond these limits, but within the limits γ', δ'—say, from γ to γ' and from δ to δ'—there are two real vertices, or the conic is a hyperbola; and for values beyond the limits γ', δ', the variable conic is imaginary.

There are four real lines $(y=0, x=\gamma)$, $(y=0, x=\delta)$, $(z=0, x=\gamma')$, $(z=0, x=\delta')$. The surface consists of a central pillow-like portion, joined on by two conical points to an upper portion, and by two conical points to an under portion, the whole being included between the planes $x=\gamma'$, $x=\delta'$.

Model 13. The form of the equation is—

$$\frac{y^2}{l^2(x-\gamma)(x-\delta)}-\frac{z^2}{l'^2(x-\gamma')(x-\delta')}+1=0;$$

the values γ', δ', lying between γ, δ; the principal conics are one of them a hyperbola, the other an ellipse, the vertices (on the axis or line $y=0$, $z=0$) of the hyperbola lying between those of the ellipse. The variable conic, for values of x between γ', δ', has two real vertices, or it is a hyperbola; for the values, say, from γ' to γ, and δ' to δ, there are four real vertices, or the conic is an ellipse; for values beyond the limits γ, δ, there are two real vertices, and the conic is a hyperbola. There are the four real lines $(y=0, x=\gamma)$, $(y=0, x=\delta)$, and $(z=0, x=\gamma')$, $(z=0, x=\delta')$. The surface consists of eight portions joined to each other by eight conical points, but the form can scarcely be explained by a description.

Model 32. The form of the equation is—

$$\frac{y^2}{l^2(x-\gamma)^2}+\frac{z^2}{l'^2(x-\gamma')^2}=1;$$

viz., the principal conics are each of them a line-pair, the variable conic is always an ellipse.

There are the two real nodal lines $(y=0, x=\gamma)$ and $(z=0, x=\gamma')$, each of these being in the neighbourhood of the axis crunodal, and beyond certain limits acnodal; the surface is a scroll, being, in fact, the well-known surface which is the boundary of a small circular pencil of rays obliquely reflected, and consequently passing through two focal lines.

Model 34. The equation is—

$$\frac{y^2}{l^2(x-\gamma)(x-\delta)}+\frac{z^2}{l'^2(x-\gamma')(x-\delta')}+1=0$$

where $x=\delta$ is not intermediate between the values $x=\gamma$ and $x=\gamma'$; say the order is δ, γ, γ'. The surface is thus a *cubic* surface; the principal conics are ellipses, having on the axis a common vertex, at the point $x=\delta$, and the remaining two vertices on the same side of the last-mentioned one. The variable conic for values between δ and γ has four real vertices, or it is an ellipse; for values between γ and γ' two real vertices, or it is a hyperbola; and for values beyond the limits δ, γ', it is imaginary. There are on the surface the two real lines $(y=0, x=\gamma)$ and $(z=0, x=\gamma')$. The surface

consists of a finite portion joined on by two conical points to the remaining portion.

Model 40. The form of equation is—

$$\frac{y^2}{l^2(x-\gamma)(x-\delta)}+\frac{z^2}{l'^2(x-\delta)^2}+1=0$$

The surface is thus a *cubic* surface; the principal conics are, one of them an ellipse, the other a pair of imaginary lines intersecting on the ellipse; for values of x between γ and δ, the variable conic has thus two real vertices, and it is a hyperbola; for values beyond these limits it is imaginary, and the whole surface is thus included between the planes $x=\gamma$ and $x=\delta$. There are the two real lines ($y=0$, $x=\gamma$) and ($z=0$, $x=\delta$).

Taking $l^2=l'^2=1$, the surface is—

$$\frac{y^2}{(x-\gamma)(x-\delta)}+\frac{z^2}{(x-\delta)^2}+1=0$$

which is a *particular* case of the parabolic cyclide.

The equatorial surfaces, not included in the preceding 78 cases, Plücker distinguishes (vol. ii. p. 368) as "gedrehte" or "tordirte," say, as twisted equatorial surfaces, the equation of such a surface is—

$$by^2+2hyz+az^2+ab-h^2=0$$

where $b=\mathrm{F}x^2-2\mathrm{R}x+\mathrm{B}$
$a=\mathrm{E}x^2+2\mathrm{U}x+\mathrm{C}$
$h=\mathrm{K}x^2—\mathrm{O}x-\mathrm{G}$ (or in particular $=-\mathrm{O}x-\mathrm{G}$).

Model A. is such a surface, being a twisted form of Model 9.

Model B. belongs to the case $a=0$; viz., the form of the equation is—

$$by^2+2hyz-h^2=0.$$

The variable conic is a hyperbola, the direction of one of the asymptotes being constant (vol. ii. p. 368).

There are, moreover, (p. 372) equatorial surfaces in which the variable conic is always a parabola, and where there are on the surface four real or imaginary singular lines.

In Model C the singular lines are all four real, but two of them coincide with the nodal line at infinity. Consequently, the variable parabola has its axis in a fixed direction. Its vertex moves along a hyperbola which has one asymptote in that fixed direction. The other two singular lines are on opposite sides of this asymptote and parallel to it. When the plane of the variable parabola passes through one of these lines, the parameter vanishes and changes sign. When it passes through the above-mentioned asymptote, the parabola reduces to the line at infinity and the plane becomes asymptotic to the surface. The latter consists of four parts, two on opposite sides of the asymptotic plane between this and one of the singular lines respectively, the other two extending from the singular lines to infinity.

The remaining three models, D, E, F, represent twisted surfaces. Of the four singular lines two are in each case imaginary. The remaining two are real on the first, coincident on the second, and imaginary on the third. Model D consists, therefore, of three, Model E of two, and Model F of one part.

The models are copies from some constructed by Epkens of Bonn. They were presented to the London Mathematical Society by Dr. Hirst, F.R.S. They have been remounted under the direction of Prof. Henrici, by M. Nolet, a student of University College, London.

Some account of complexes and complex surfaces will be found in Dr. Salmon's Geometry of Three Dimensions (3rd edition, pp. 405, 493, 566, 570).

Professor Cayley's paper is printed in vol. iii. of the London Mathematical Society's Proceedings, pp. 261–285.

123a. Rough Model of Steiner's Surface.

Prof. Cayley.

Steiner's surface is the quartic surface represented by the equation $\sqrt{x}+\sqrt{y}+\sqrt{z}+\sqrt{w}=0$; where the co-ordinates x, y, z, w of a point are proportional to arbitrary multiples of the perpendicular distances from four given planes; in the model, x, y, z, w are proportional to the perpendicular distances from the faces of a regular tetrahedron, the co-ordinates being positive for a point inside the tetrahedron.

The surface may be regarded as inscribed in the tetrahedron, touching each face along the circle inscribed in the face. The general form is that of the tetrahedron with its summits rounded off, and with the portions within the inscribed circles scooped away down to the centre of the tetrahedron, in such wise that the surface intersects itself along the lines drawn from the centre to the mid-points of the sides (or what is the same thing, the lines joining the mid-points of opposite sides). The lines in question produced both ways to infinity are nodal lines of the surface, but as regards the portions outside the tetrahedron, they are acnodal lines, without any real sheet through them; and these portions of the lines are not represented in the model.

The sections by a plane parallel to a face of the tetrahedron are trinodal quartics, which (as the position of the plane is varied) pass successively through the forms:

1. Four acnodes.
2. Trigonoid, with three acnodes.
3. Tricuspidal.
4. Trifoliate, with three crunodes, cis-centric.
5. Do. with triple point at centre.
6. Do. with three crunodes, trans-centric.
7. Twice-repeated circle.

The three nodes being in each case the intersections of the plane by the nodal lines, and the twice-repeated circle being the circle inscribed on the face of the tetrahedron.

123b. Model of a Cubic Surface.

Prof. O. Henrici, F.R.S.

The equation to this surface is $xyz=k^3(x+y+z-1)^3$. There are 3 biplanar nodes as shown on the model. The 27 straight lines on the surface are all real, but coincide 9 to each with the 3 black lines drawn on the model.

123c. Sylvester's Amphigenous Surface, a surface of the ninth order.

Prof. O. Henrici, F.R.S.

This surface is connected with the reality of the roots of equations of the ninth degree.

124. Models. A series illustrative of Plücker's Researches in Geometry of Three Dimensions. *Prof. Hennessy, Dublin.*

125. Diagrams (48) showing the Fundamental Principles of the exhibitor's "Organic Geometry of Form."

Prof. Franz Tilser, Prague.

above work demonstrates the necessity for a reform in geometry, and es the necessary basis for establishing a new system adapted to satisfy uirements of an exact science. To the above are added 7 "Paragram" , representing in natural organic connexion a synopsis of the principal ts to be observed in every graphical representation.

5. Model of the ruled cubic surface called the **Cylindroid.**

Dr. Robert S. Ball, LL.D., F.R.S.

surface was discussed by Plücker in connexion with the theory of ear-complex. The kinematical and physical significance of the surill be found in the "Theory of Screws." The equation of the surface $+y^2)-2xy=0$.

7. Models (6) illustrating the relative bases of Descriptive etry and the Organic Geometry of Form.

Prof. Franz Tilser, Prague.

8. Drawings. A collection, executed by the Students of ohemian Polytechnic Institute, illustrative of the instruction ed in the subject of Organic Geometry of Form.

Prof. Franz Tilser, Prague.

9. Two specimens of Stereometrical Wire Models, etters on cork.

Prof. J. Joseph Oppel, Frankfort-on-Maine.

0. Two specimens of Trigonometrical Wire Models, letters. *Prof. J. Joseph Oppel, Frankfort-on-Maine.*

1. Two specimens of Stereometrical Models of d, with letters.

Prof. J. Joseph Oppel, Frankfort-on-Maine.

auxiliary lines, diagonals, &c. are distinguished by wires of different or thicknesses. They are in many cases movable, so that the perfect can be constructed before the eyes of the pupil.
iliary planes are also distinguished by their colour. The angular are provided with metal pins, to which letters on cork plates can be d, so as to be turned upright towards the observer.
se models have proved highly serviceable for instruction during the 0 years.

12. Large Model of an Ellipsoid, of white cardboard, turned stand. *Prof. Dr. A. Brill, Munich.*

13. Cardboard Models of Surfaces of the second r, on frames. Made up of circular sections. The sections ttached to each other. *Prof. Dr. A. Brill, Munich.*

is collection of models consists of :—

1. An **Ellipsoid** having 20 circular sections;
2. An **Ellipsoid** having 30 circular sections;
3. A **Hyperboloid** of one sheet;
4. A **Hyperboloid** of two sheets;
5. An **Elliptic Paraboloid;**
6. A **Cone** in two sheets; and
7. A **Hyperbolic Paraboloid.**

[redacted]

141. Series of Cardboard Models of Surfaces, of the second order, in a cardboard box. The sections are not attached to each other. *Prof. Dr. A. Brill, Munich.*

These models are distinguished from those in common use by their mobility, by means of which each one represents not only a single ellipsoid or hyperboloid, but also a host of surfaces of one or the other kind. For when the angle of inclination of the circular sections is altered, in a direction easily recognised by pressing or drawing out the model, there will be obtained a simple but infinite system, the individual forms of which can be converted from a flat figure through gradually-changing solid bodies to just such another figure with a different relation of axes, without, however, losing its properties.

The equations representing these systems of surfaces are in rectangular co-ordinates :—

For central surfaces :

$$\frac{x^2}{a^2} + \frac{y^2}{\cos^2\psi}\left(\frac{1}{a} - \frac{1}{k}\right) + \frac{z^2}{k\sin^2\psi} = 1, \text{ or } = 0 \text{ (cone).}$$

For the elliptic paraboloid :

$$\frac{x^2}{a^2} + \frac{y^2}{a^2\cos^2\psi} - \frac{2z}{k\sin\psi} = 0$$

Where 2ψ is the inclination of the circular sections, and a and k are real constants. From the first equation it appears that among the series of ellipsoids there will always be a sphere.

142. Model of a Surface of the third order, made in plaster of Paris, with 27 real right lines.

Prof. Dr. Christian Wiener, Carlsruhe.

The construction of the model is described on a placard fixed to the model.

143. Model of the same surface of the third order, in [illegible] of cardboard, with 27 real right lines.

Prof. Dr. Christian Wiener, Carlsruhe.

144. Poinsot's Star Polyhedra. *Max Doll, Carlsruhe.*

These models show the star dodecahedron with 20 points, the star dodecahedron with 12 points, the icosahedron and dodecahedron.

145. Curvilinear centre surface of the Ellipsoid, in [illegible] [illegible] of the axes of the ellipsoid, [illegible]

Ludwig Lohde, Berlin.

146. Dupin's Cyclides, according to the calculation of Professor [illegible] Model [illegible] Kummer. [illegible] der Wissenschaften zu Berlin, [illegible]

Ludwig Lohde, Berlin.

147. Kummer's Cyclide. *Ludwig Lohde, Berlin.*

148. [illegible]-surface [illegible] a [illegible] number of tetr[illegible]

[illegible] Academy of Sciences by Professor [illegible]

Ludwig Lohde, Berlin.

152. Maximum of Attraction of the Earth's Surface.

Ludwig Lohde, Berlin.

153. A Geometric Body, executed in plaster of Paris, called "**Podoid;**" a transcendental curved surface, which is determined by the variable parallel co-ordinates μ, ϕ, and κ, whose equation represents the elliptic function

$$\mu=\int_0^{\phi}\frac{d\phi}{\sqrt{(1-\kappa^2\sin^2\phi)}}=F(\phi,\kappa)$$

The construction in plaster of Paris embraces the limits $\kappa=+1$ to $\kappa=-1$ and $\phi=0$ to $\phi=\pi$.

154. The same Podoid, executed on a smaller scale, embracing the limits $\kappa=+1$ to $\kappa=-1$, $\phi=0$ to $\phi=2\pi$.

Prof. Dr. Edward Heis, Münster, Westphalia.

155. Right double circular Cone, of white wood.

Prof. Borchardt, Berlin.

On the one sheet of the double cone are shown, by sections, the circle, the ellipse, and the hyperbola; on the other, the circle, the parabola, and the corresponding hyperbola. The model takes to pieces at the sections.

156. Elliptic Cone, of white and brown wood.

Prof. Borchardt, Berlin.

On the oblique cone are shown the two circular sections, and the elliptic, hyperbolic, and parabolic sections. At the sections of the ellipse and parabola the model takes to pieces; the other sections are shown by the lines defined by the dark and light wood.

157. Ruled Surface of the fourth degree.

Prof. Borchardt, Berlin.

This model represents a surface of the fourth order determined by the equation—

$$\frac{3x^2}{(z-a)^2}+\frac{3y^2}{(z+a)^2}=1.$$

The surface has two pairs of right lines, between which lies a finite sheet of the surface as shown on the model, whilst beyond each pair of right lines there extends a second and third infinite sheet of the surface. Every horizontal section of the surface is an ellipse. Of these are shown the circular section corresponding to $z=0$, and the two ellipses corresponding to $z=\pm\frac{a}{2}$. The model can be taken to pieces at each of these sections.

158. Rectangular Parallelopiped, intersected by a skew surface. *Prof. Borchardt, Berlin.*

159. Right Circular Cylinder, with spiral surface intersecting it. *Prof. Borchardt, Berlin.*

These five models, Nos. 155–159, are executed by the late *Ferd. Engel*, known from the drawings, which he has furnished to *Prof. Schellbach's* 'Darstellende Optik."

160. String Model, representing a hyperboloid of one sheet. On it are shown the principal ellipse, the asymptotic cone, and a tangential surface, in threads of different colours.

Dr. Wiecke, Cassel.

This model represents by means of strings (kept tight by springs) of different colours the hyperboloid of one sheet and its principal auxiliary surfaces. The two sides of the surface are shown by the green and red strings respectively; the principal ellipse is given by the points at which the strings pass through the network stretched on the frame; the asymptotic cone is shown by yellow, and a tangent plane by white strings.

161. Model in plaster of Paris, representing the eighth part of the former with a developable normal surface, lines of curvature and edge of regression.

Dr. Wiecke, Cassel.

This plaster model represents the eighth part of the surface of an hyperboloid of one sheet; it is constructed on the principal ellipse, and shows the principal axes. It is also attempted to demonstrate on this hyperboloid the lines of curvature of the first and second kind, first investigated by Monge. On this account the hyperboloid is bounded on the side opposite to the principal ellipse by a normal surface of which the directrix is one of the lines of curvature of the first kind. The normals are drawn in this normal surface, and produced to meet in the edge of regression, which with two of the normals will then become the boundaries of the normal surface.

161a. Collection of 45 geometrical solids in cut crystal, for purposes of demonstration.

Madame Wentzel.

162. Intuitive Method of Projection, by movable planes. Cardboard models (19), practically illustrating problems of space.

Frère Memoire Piron.

162a. Open Frames containing **Photographs** for teaching by projection.

T. and A. Molteni, Paris.

162b. Projection Apparatus, polyorama for superposed images.

T. and A. Molteni, Paris.

IV.—REPRESENTATION OF FIGURES IN SPACE BY MEANS OF DRAWINGS ON A PLANE.

163. Diagrams and Models, illustrative of **Descriptive Geometry,** executed by the Frères de la Doctrine Chrétienne, of Paris.

Professor Pigot, Dublin.

164. Drawings, executed in the college by the students, showing the nature of the courses of **Descriptive Geometry** and engineering.

Professor Pigot, Dublin.

165. Specimens of a series of **simple folding models** for illustrating the various propositions in **Descriptive Geometry.**

Prof. Osborne Reynolds.

These are specimens of a series of models designed for illustrating the various propositions in descriptive geometry. They are especially designed for lecturing purposes, for which their simple construction, and the capability which they possess of folding into small compass, well adapts them.

166. Stereoscopic Figures, for demonstration and use in the study of stereometry and spherical trigonometry. Edited by Julius Schlotke. *L. Friederichsen and Co., Hamburg.*

167. The principal Problems of Descriptive Geometry, represented by stereoscopic figures, by Julius Schlotke. *L. Friederichsen and Co., Hamburg.*

168. Stereoscopic representation of a number of the most important crystals, their combinations, &c., by Julius Schlotke. *L. Friederichsen and Co., Hamburg.*

The stereoscopic figures of Schlotke are as yet the only ones of their kind in use for illustrating instruction in descriptive geometry and crystallography, in polytechnic and other higher educational institutions, where they are much appreciated.

More particularly the division of crystallography is recommended, as it renders unnecessary the usual expensive models, and, better than those models, demonstrates the combinations and growth of crystals.

A stereoscopic apparatus is placed near the objects.

SECTION 3.—MEASUREMENT.

West Gallery, Ground Floor, Rooms H. K.

I.—SPECIAL COLLECTIONS.

Collection of Standard Measuring Apparatus contributed by the Standards Department of the Board of Trade.

A.—*Comparing Apparatus, &c. for Standard Weights and Measures.*

169. Comparing Apparatus for End-Standards of length. Used by Mr. Sheepshanks in the work of the Commission for Restoration of the Imperial Standards, 1844–1850. Constructed by Troughton and Simms.

The standard and compared end-bar are placed successively on the V supports, with one defining end in contact with the left hand stud and the other defining end with the suspended gravity-piece interposed between it and the right hand stud. The last-mentioned stud is to be gently pressed forward by the micrometer screw until it just holds up the gravity piece in position, thus ensuring constant pressure for each observation. The readings of the micrometer being taken, the difference of the two readings shows the difference in length of the two end bars to less than 0·0001 inch, which is the value of one division of the micrometer.

To obtain results with scientific precision the temperature of the measuring axis of each bar during the comparison should be known, as well as its rate of expansion. The temperature and length of the bar connecting the two studs and of the metal of the apparatus should also be constant.

170. Two Lever Frames, with rollers for supporting standard bars. Such lever frames are used for supporting all the Imperial Standard yards made by the Commission for restoring the Standards. Constructed by Troughton and Simms.

Each bar is supported on the eight rollers of the two lever-frames, which are placed symmetrically under the bar, so that the upward pressure of each of the eight different rollers is necessarily equal, and the length between the defining points of the bar is not altered by its flexure. Equal intervals of supports $= \dfrac{\text{length of bar}}{\sqrt{n^2-1}}$, where n is the number of supports.

171. Double Micrometer Microscope for comparing the smaller subdivisions of standards of length. Constructed by Troughton and Simms.

It has a moveable eye-piece with a double lens, sliding upon a horizontal plate, and two micrometers; and has two object-glasses, each with a double

lens, sliding on a horizontal plate parallel to the other plate. The measuring field is about two centimetres in extent, or a little less than 1 inch. Value of one division of each micrometer = 0·00003097 inch, or 0·0007866 millimetres.

172. Apparatus for determining the Expansion of Standard Bars. Constructed by Troughton and Simms.

The trough containing the steel bar with projecting points, distant 1 yard and 1 metre, is filled with melting ice to secure constant length at the temperature of 0° C. The standard bar is placed in the lower trough, with two standard thermometers, and is raised gently against the points. Their impression shows the constant length on the bar at its noted temperature in ordinary air. Next fill the lower trough with melting ice, and take impressions to show the constant length on the bar when at 0° C. Then fill the lower trough with water, and raise to boiling point, or other less high temperature, by the heat from the *gas jets* underneath, and take impressions to show the constant length on the bar when at 100° C., &c. From the difference of these lengths accurately measured under micrometer microscopes, the rate of expansion of the bar is deduced.

173. Large Callipers for measuring diameter and depth of cylindrical or other measures. Constructed by Troughton and Simms.

These are made on the same principle as the instruments used for measuring shot and the bore of guns at Woolwich. They measure diameters up to 24 inches and within 0·001 inch by the aid of a vernier.

174. Model of Sub-divided Yard with comparing apparatus, for the use of local inspectors of weights and measures. Constructed by Troughton and Simms.

The tested yard measure is placed with its zero defining line immediately under that of the standard. By running the eye-piece along the upper guide bar, each defining line is accurately compared and differences determined to less than 0·01 inch by means of the small supplementary sub-divided inch measure placed also under the eye-piece. This apparatus is described and illustrated in Appendix III., 7th Annual Report of Warden of the Standards, 1873.

175. Spherometer for measuring spherical curves, with true gun-metal plane. Used for measuring the flexure of the middle of the glass disc placed upon the Imperial Standard bushel. Constructed by Troughton and Simms.

When the horizontal plane is made to rest with its three triangular flattened points upon the true plane, the central screw with its micrometer head is accurately adjusted in the same plane, and its reading noted. By substituting for the plane the surface to be tested, its convexity or concavity is determined from the difference of the reading of the micrometer, either − or +. Value of one revolution of the screw = 0·01 inch, and of one division of the micrometer = 0·0001 inch. By interposing a bright beam of light between the point of the screw and the surface tested, and by estimation of 0·1 division, accurate measurements have been made to 0·00001 inch. This instrument is described in Appendix X., 6th Annual Report of Warden of the Standards, 1872.

176. Cathetometer for vertical measurements. Constructed by Troughton and Simms.

For example, for accurately reading a barometer or manometer: place the cathetometer at a convenient distance, and adjust the cobweb line of the upper telescope to the level of the mercury in the glass tube, and that of the lower telescope to the level of the mercury in the reservoir. The difference of the two readings on the graduated scale of 42 inches gives the length of the column of mercury to 0·001 inch, by aid of the vernier.

177. Stereometer for ascertaining the density of bodies by determining their volume. Constructed by Troughton and Simms.

This instrument was invented by M. Say (Annales de Chimie, t. xxiii. p. 1, 1797), for determining the specific gravity of gunpowder, and was used with some improvements by Professor W. H. Miller (See Phil. Trans. 1856, part iii. p. 800) for determining the density of the platinum *Kilogramme des Archives*, during his work of restoring the imperial standard pound. The solid body tested is placed in the receiver communicating with the upper end of a vertical glass
tube, the lower end of which communicates with that of a second glass tube
having its upper end open to the air. The body should nearly fill the receiver,
which is screwed up air-tight in its place. Mercury is poured into the second
tube, and can be discharged by a stopcock at its lower end. Differences h
the relative height of the mercury in the two tubes are noted as indicating th
volume of compressed air under the two conditions by means of the cathe
meter, when the body is in the receiver and when it is removed. The volu
of the body is deduced from the volume of the mercury contained in t
tube between the different heights noted.

178. Balance of new construction oscillating with s
springs. This has been recently constructed by Mr. Oertling f
a design of Mr. Artingstall.

The principle is, that, instead of the beam and pans being suspend
knife-edges, thin elastic steel springs are used, and adjustments of
edges from time to time are thus avoided. Its advantages are like th
Steinheil's silk ribbon balance in its simple construction and durability
extreme scientific accuracy is not required; but it appears to be wa
the sensibility and stability requisite for a balance of precision.

179. Model Kit of Apparatus for Local Inspe
Weights and Measures. Constructed by Mr. Oertling.

This portable collection of all the necessary apparatus for
imperial weights and measures has been taken from the Ne
Vérificateurs, employed in France for verifying metric weights an
with a view to its adoption in this country. It includes a Septi
by means of which a weight of 56 lbs. is compared against 8 lbs
the standard weights.

180. Experimental Gasholder for determining
temperature. Constructed by Messrs. Wright & Co.

By raising and lowering the bulb of the thermometers, the
are made to slide through the top of the gasholder, the tem
gas or air at various heights inside the bell can be read off th
side, and the mean temperature determined.

181. King's Pressure Gauge, showing mechanical pressure of gas or air. Constructed by Mr. Sugg.

Standards Department, Board of Trade.

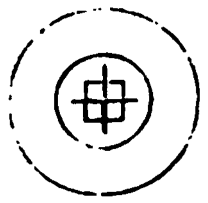
The amount of the mechanical pressure of gas or air contained in a gasholder is shown by this pressure gauge, when it is put in communication with the gasholder by an air-tight tube. The surface of the water in the cistern of the pressure gauge is depressed by the force of the gas or air, and alters the level of a metal cup floating on it. A cord is attached to the float, and passes over a pulley, the spindle of which, aided by friction rollers, carries a pointer moving on a graduated dial, and thus indicates the amount of pressure in hundredths of an inch.

Specimens of Standard Weights and Measures.

182. Copy of Standard Weight, 112 lbs., of Queen Elizabeth.

One of two similar bronze weights deposited in one of the old Treasuries of the Exchequer, and fully described in App. IV. to the 7th Annual Report of the Warden of the Standards.

183. Gilt Steel Yard, line measure, of the same form as the imperial standard yard. Constructed by Troughton and Simms.

Well-holes are cut down to the mid-depth of the bar, where the defining lines are cut upon gold studs, thus , the measure being taken at the middle portion of the central transversal line, intercepted between the two longitudinal lines. These lines, including the two transversal guide lines, one on each side of the defining line, are 0·01 inch apart.

184. Steel Yard End Measure, showing the form of end-standard yard adopted by the Standards Commission. Constructed by Troughton and Simms.

The form of the defining ends is that of a spherical surface, whose centre is the centre of the division line in the middle of the bar's length. The material of the defining end is a highly polished plug of agate, shrunk into a slightly conical hole at the end of the steel bar.

185. Steel Foot End-Measure. Constructed by Troughton and Simms.

186. Two Steel 6-inch End-Measures, one finished and one unfinished. Constructed by Troughton and Simms.

187. A 10-Foot Measuring Rod, of pine wood, bound with brass. Constructed by Troughton and Simms.

188. A 3-Foot Measuring Rod, of pine wood, bound with brass. Constructed by Troughton and Simms.

189. One lb. Avoirdupois Weight, of gun-metal, electro-plated with nickel.

Constructed as an experiment of coating brass or bronze with unoxidisable metal. Oxidation, however, is found to occur at points on the surface of the bronze under the nickel coating.

190. One Kilogram Weight, of gun-metal, nickel-plated.

191. Set of Glass Avoirdupois Weights, from 7 lbs. to 1 oz., made experimentally of green bottle glass, not subject to hydroscopic influences. The larger weights adjusted with lead shot.

192. Set of Metric Weights, from 1,000 grammes to 1 gramme. Constructed by Salleron, Paris, of opaque glass, adjusted with mercury to the density of brass weights, and hermetically sealed.

193. Specimen of an Enamelled Iron Weight of 56 lbs., made to resist oxidation, by De Grave, Short, and Co.

194. Specimen of a Patent Brass-cased Iron Weight of 14 lbs.

195. Section of a Patent Brass-cased Iron Weight of 14 lbs., showing mode of construction.

196. Copy of Standard Cubic Foot nickel-plated, with filling apparatus. Constructed by G. Glover & Co.

This is a copy of the standard cubic foot bottle, the primary unit from which the gas-measuring standards were derived. It was verified by weighing its contents of distilled water = 62·321 pounds avoirdupois, according to Sir G. Shuckburgh's determination of the weight of a cubic inch of water. It is used as a direct transferrer of a cubic foot of gas or air, which is driven out from it by raising the cistern and thus introducing water from underneath up to the defining line of a cubic foot. By this arrangement, the nearly undisturbed surface of the water is carried upwards and gradually through the entire height of the bottle, without risk of forming air bubbles.

197. Copy of five cubic feet Gas-measuring Standard, made of anti-corrosive metal, by G. Glover and Co., with scale of capacity graduated in feet and minute fractional parts.

The bell is equipoised when at various depths of its immersion in the water of the cistern by a balance, a portion of which hangs from a cord working in a groove in the circumference of a cycloidal wheel, and attached to the axis of the wheel from which the bell is suspended.

198. Copy of a Standard Test Dry Gas Meter, with testing table. Constructed by G. Glover & Co.

Such test gas meters are authorised to be used for testing stationary meters, where the larger gas measuring standards cannot conveniently be used. The accompanying testing table shows it fitted with thermometers and pressure gauges, and with stand pipes for outlet and inlet communications.

). **Model of a Petroleum Testing Apparatus**, for ascer-
g the temperature at which its inflammable vapour ignites.
ıed by T. W. Keates, Esq., and proposed as a standard for use
ordance with authoritative uniform regulations. Constructed
w & Co.

). **A Brass Scale** of 41 inches, divided into tenths, and of a
divided into millimetres; both scales at 62° Fahr. Con-
ed by Dollond, and now the property of Mr. Petrie.

possesses some scientific interest, having been compared several times
Shuckburgh's scale by Capt. Kater. He found in 1830, and again in
that 36 inches of the scale = 35·99893 inches of the imperial
d yard, afterwards destroyed in 1834; and assuming the scale of
to be perfectly correct, that the metre = 39·37045 inches.
pared at the Standards Office in February 1876, with the bronze official
which has a standard metre at 0° C. marked on the same bar. From the
of six comparisons, 36 inches of the scale = 35·99961 inches of the
l standard yard, and the metre = 0·999684 metre, being 0·316
tre less than the *Mètre des Archives* at the normal temperature
.

OF OLD STANDARD MEASURES LENT BY THE MAYOR AND CORPORATION OF THE CITY OF WINCHESTER.

.. **A very old Steelyard Weight,** date unknown.
. at Hyde Abbey, Winchester.

2. **Set of Standard Troy Weights,** from 256 oz. to
of Queen Elizabeth. Dated 1588, being the year in which
anted a charter to the city.

3. **Set of Standard Weights** (avoirdupois), 56 lbs., 7 lbs.,
2 lbs., 1 lb., of Queen Elizabeth, dated 1588, being the year
ich she granted a charter to the city. From the Muniment
, Winchester.

4. **Standard Weights** (56 lbs., 28 lbs., 14 lbs., and 7 lbs.).
sed to be of the date of Edward III. From the old Muni-
Room over the West-gate, Winchester.

5. **Standard Yard Measure.** Henry VII. From the
ment Room, Winchester.

6. **Standard Quart and Pint of William III.** Dated
. From the Muniment Room, Winchester.

7. **Standard Gallon, Quart, and Pint of Queen
abeth,** dated 1601. From the Muniment Room, Winchester.

8. **Standard Winchester Bushel,** given to the Cor-
tion by Henry VII. in the year 1487.

9. **Standard Winchester Gallon,** given to the Cor-
tion by Henry VII., in the year 1487.

219. Paddle Apparatus, by means of which Dr. Joule determined the dynamical equivalent of heat. Described in Philosophical Transactions for 1850, page 65. *Sir William Thomson.*

220. Cast-iron Vessel, containing **Friction Disks,** to revolve under mercury. Used in 1849 to determine the mechanical equivalent of heat from the friction of cast-iron against cast-iron. The equivalent arrived at was 775 ft. lb.

221. Electro-magnet consisting of a broad plate of half-inch iron, having a bundle of copper wires coiled round it. Employed in the first determination of the mechanical equivalent of heat.

222. Apparatus for determining the temperature of water at its maximum density.

Used in the experiments on atomic volume and specific gravity by Playfair and Joule (Memoirs of the Chemical Society, vol. iii., 1846). It consists of two tall vessels, connected together by a stop-cock at the bottom, and a trough at the top. A minute difference of the temperature of the water in one of the vessels from that of the maximum density, determines a flow through the trough to the vessel still nearer the temperature of maximum density. The temperature of maximum density of water was thus shown to be 39·1.

II.—MEASUREMENT OF LENGTH.

A. Standard Scales.

224. Brass Standard Scale (Bird's). Date about 1750. *Royal Society.*

225. Brass Standard Scale (Sir G. Shuckburgh's). *Royal Society.*

227. Standard Scale, in porcelain, showing the relations of modern British and ancient Great Pyramid inches. *Prof. Piazzi Smyth.*

This scale was prepared to order by M. Casella, of London. It exhibits side by side 25 modern British inches and the same number of ancient Great Pyramid inches, similarly subdivided.

The 0 divisions of both sets of inches coincide at the left hand exactly, but from thence the gradual growth of the difference of 0·001 of an inch per inch in favour of the Great Pyramid scale may be traced, until at the 25th inch the difference amounts to 0·025 of the British inch. At that point, however, it is to be noted that 25 Great Pyramid inches are just one 10-millionth of the earth's semi-axis of rotation, or the nearest earth commensurable and scientific unit ever yet proposed as a standard of length.

Standard Five-Inch Scale, in smoky agate, for micro-
;ht. *Prof. Piazzi Smyth.*

terial, which came from Brazil, and was worked up and divided y M. Jules Salleron, Paris, was chosen as being a natural product nfinite age, and therefore settled condition, harder than steel and oxidisable. The particular standard length adopted is shown for c sight. It depends not on one pair only, but on 20 available pairs ich five inches apart, drawn with a fine diamond point, and is in- typify both one fifth of the sacred cubit of Israel and one 50 of the earth's semi-axis of rotation.

Standard Five-Inch Scale, in white chalcedony, for
pe sight. *Prof. Piazzi Smyth.*

terial, which came out of some ancient Roman palace, is chosen ne reasons as that last described. The scale is divided on the same

Standard Five-Inch Scale, in red porphyry, for
pe sight. *Prof. Piazzi Smyth.*

terial came from an Imperial Roman palace to which it had been r the Cæsars from some far more ancient Egyptian temple. It was quarried by the Egyptians of 3,500 years ago in the rich porphyry tween Thebes and the Red Sea, and it has been adopted for the same the preceding examples, and the scale is divided on the same

Standard of Length, derived from the earth's polar
ich is unique and common to all terrestrial meridians.
Professor Hennessy.

ndard is a bronze bar, which, at 15° of temperature centigrade, is e fifty millionth part of the earth's axis. This standard was first y Professor Hennessy, and a similar standard was afterwards sug- Sir John Herschel.

Steel Chain, of fifty links, whose total length is the
part of the earth's axis, or very nearly 500·5 English
It is nearly equal to the half chain of two perches in Irish
n measure. *Professor Hennessy.*

Standard Yard Measure, German Silver, with one
divided to inches and 10ths. Temperature 60° Fahrenheit.
Elliott Brothers.

Steel Tape Measure, 66 ft. For testing tapes, divided
nd inches on one side and links on the other.
Elliott Brothers.

Scales, of boxwood, showing the equivalents of English
reign measures of length. *Aston & Mander.*

[redacted]

The bevel edged set square side is used to show the divisions coinciding and the equivalent values of English and Foreign measures of length may thus be readily obtained.

245. Plotting Scales. Ivory. Two specimens, to show fine and accurate dividing. *Aston & Mander.*

No. 1 shows two chains to the inch, represented by 200 divisions to the inch.

No. 2 shows one chain to the inch, represented by 100 divisions to the inch.

247. Longitudinal Measure, according to natural principles. *Hans Baumgartner, Basle.*

250. Half Metre, maple, with points.
Geneva Association for Constructing Scientific Instruments.

251. Brass Metre. (Model of the Grand Duchy of Baden.)
Geneva Association for Constructing Scientific Instruments.

252. Double Steel Metre, with points. (German Model.)
Geneva Association for Constructing Scientific Instruments.

253. Brass Standard Metre. (Swiss Model.)
Geneva Association for Constructing Scientific Instruments.

The Geneva Association for Constructing Scientific Instruments possesses in its laboratories a machine for the division of straight lines, to the construction of which it has endeavoured to apply all the improvements of modern science. Its efforts have been crowned with success, and now the increasing reputation of this machine, which may be considered as the most complete at present existing, has gained for the Geneva Association orders for metrical standards from several European Governments.

The machine is worked automatically, that is, all the process of dividing is done mechanically. Thus it avoids, apart from the inaccuracy consequent on the temperature of the operator, the errors proceeding from the inattention or fatigue of the latter. Mechanical action has, moreover, the advantage of being more regular, seeing that the motive power is always equal.

An ingenious contrivance enables the correcting, during the division of errors due to a change of outward temperature, and to effect at any temperature an exact division at 0°. By the same means, a division of any length may be made, however immeasurable may be ratio of the thread of the screw of the machine to the length of the division required.

The curve of the screw has been thoroughly studied and corrected, so as to guarantee accuracy to the $\frac{1}{100}$ of a millimetre.

This machine for dividing straight lines has been used to effect the normal division of the large machine for dividing circles which stands by its side on the same bed of concrete. This application has been the means of exactly ascertaining the coefficient of dilatation of the machine for dividing straight lines. The maximum of error found in the division of the normal circle was less than a second. It is impossible to expect greater accuracy when it is remembered that the arc of a second on the circumference of the divided circle represents about $\frac{1}{400}$ of the millimetre.

59. **Standard Metre,** with rack action to be used as a
ine for dividing other metres.

Geneva Association for Constructing Scientific Instruments.

s instrument may be used both as a comparative indicator, and as a ne for dividing fractions of the metre, for the use of comptrollers of ts and measures. A small marker slides at will, by means of a rack, the meter. A very simple lock action enables the millimetric displace- of the indicator to be registered without any other divisional check.

30. **A 6-foot Measuring Rod,** for uneven ground, for
eering and scientific purposes. Designed by Edward sley, F.R.A.S., and made by Messrs. T. Cooke & Sons.

Edward Crossley, F.R.A.S., Halifax.

e apparatus consists of a wooden rod 6 ft. in length, with metal ter- tions containing spherical cups fitting on to spherical heads upon tripod s. Three tripod stands are required. Each terminates in a flat ring which the base of the short pillar carrying the spherical head is table, and to which it can be clamped. The rod is supported by two l stands, while the third is set forward to receive the rod in its next on. The inclination of the rod is read off to half-a-minute in each on by means of a level and arc attached to the centre of the rod. The horizontal distance is then obtained by applying a tabulated correction ch inclination of the rod.

is instrument will give an accuracy of 1 in 10,000 over any sort of nd, even with a gradient of one in four.

66. **Ivory Pocket Measures.** *T. Hawksley.*

69. **Foot-scale-plate.** A rectangular brass-plate containing
ty different foot-scales, made in 1769 by Adam Steitz in terdam. It is a copy from the original deposited in the Town of Amsterdam. *Professor Buys-Ballot, Utrecht.*

75. **Meter-measures,** constructed of mica. (*See* Nos. 60, , 2591, &c.) *Max. Raphael, Breslau.*

hese measures have the advantage of being transparent, and may serve copying geometrical drawings. Owing to their remaining unaffected by ordinary changes of temperature they may also be used as *standard sures.*

189. **Meter Scale** with double divisions, for 0° and 20° C., Breithaupt and Son, in Cassel.

Mathematical and Physical Institute, Marburg (Prof. Dr. Melde).

195. **Standard Double Meter** on steel, in a case.

F. W. Breithaupt, Cassel.

The normal double meter is a terminal surface measure, as well as a rtise-gauge, with divisions throughout in centimeters, and on both the end meters in millimeters. This double meter is graduated on the precision

e exterior **diameter** of the
f the rings to be spanned
er.

Arsenal of St. Petersburg.

ch is placed right across the
1 be moved; the one arm is
ice of the cannon, whereupon
. into connexion with the sur-
manner that this contact lever
ne vertical screw at the greatest
y determine the diameter, the
g off the apparatus from the
and slided so until the contact
erves also for measuring the
us has been constructed and

atus for **measuring** the
of the **bore** of **cannons.**

?. Brauer, St. Petersburg.

:h of the cannon by means of
ls fixed which can be turned
ır micrometer and a position

ırrel, being turnable about the
ass plate with engraved cross.
fore mentioned, and the deter-
Filar micrometer indicates the
e and the eccentricity of the

bitor for the Russian Marine

; the **Bore of Cannons**

?. Brauer, St. Petersburg.

slide two parallel rods length-
rries the scale, the other the
ınder by means of springs, so
the bore to be measured. As
ıstment, the sliding rods are
cular under the sliding rods is
reatest diameter, which has to
ıamber of a breech-loading gun
' two rings has to be added, of
viewing the scale. The two
ır bars, and these bars have a
the operation of measuring is

267c. Apparatus constructed for measuring the outer diameter of small cylinders with an accuracy of 0·001 inches.
G. Brauer, St. Petersburg.

This apparatus, which was employed at the experiments as to the elasticity of gun-metals, steel, cast-iron, &c., in Russia, is provided with an immoveable pillar and a contact-lever, which can be displaced by means of a screw-movement. The cylinder to be measured is placed between the two, and the screw turned until the lever points to zero, and then the reading is effected by the vernier of the longitudinal scale.

267d. Apparatus for Measuring the Length of the Impressions made by the **Rodman Scale.**
Technological Institute at St. Petersburg.

The copper plate, on which is the impression to be measured, is placed on the sledge of the apparatus, and then one end of the impression after the other brought under the thread cross of the microscope by means of the screw of the sledge, whereupon the reading can be made at the top of the screw. By means of an ocular micrometer also shorter longitudinal dimensions can be measured.

The apparatus belongs to the Technological Institute at St. Petersburg.

271. Calliper, with Dial, of the inch English measure, divided into eighths of an inch. *M. Isoard fils.*

272. Calliper, with **Dial** of two centimetres, divided into tenths of a millimetre. *M. Isoard fils.*

283. Cylindrical Gauges differing in diameter by one ten-thousandth of an inch. Other gauges and specimens of surfaces.
Royal School of Mines.

284. Universal Calliper, with slide and reverse action.
Geneva Association for Constructing Scientific Instruments.

Instrument of measurement, for ascertaining equally the thickness, the inner diameter of tubes, and their height. The latter by revolving the moveable nozzle.

286. Apparatus for measuring accurately the **Diameter of Wires,** for testing whether pivots and other turned objects are perfectly circular in form, and for the determination of the error when they are not truly circular.
Landsberg and Wolpers, Hanover.

287. Apparatus for measuring the Thickness of thin metal plates, sheets of paper, &c.
Landsberg and Wolpers, Hanover.

288. Calliper-Compasses for larger arcs.
Landsberg and Wolpers, Hanover.

288a. Photographs, showing two kinds of machines measuring with great precision the alterations in shape produced in metals by tension and compression. *Dumoulin Froment, Pa*

ve scale is intended for engineers, steam boiler makers, surveyors, and others, for copying maps, plans, &c.
be of great advantage in the projection of railway lines, the requiring only to be adjusted to the situation in order to ascer- the line can be most favourably traced, and expensive cuttings In regard to such surveys, as well as in the control or examination lines already traced and sketched (for which purposes either the out according to certain radii, or compasses, are used at present), yment of the curve scale will save the tedious trouble of experi- since the correct curve can be immediately determined and read by this instrument.
manufactures, also, and almost all technical pursuits, will find the le very useful for determining the radius of part of an arc of a circle, three points are given, as, for instance, in arched steam boiler

t, in all cases where part of an arc of a circle, or three points of the given, the radius can be read direct, and without loss of time, in a hitherto unknown.
desired to take the radius of a given curve by means of the scale, le bar of the same is placed on the curve line, and the scale is then far upwards or downwards until the curve line meets in three com- dly described points of the scale. The number indicated gives the the curve in centimeters, if the curve is drawn in its natural size.
ever, the drawing of which the radius of the curve is to be deter- sketched, as is usually the case, in a reduced scale, the radius must be multiplied with the proportional number of the reduced

ample, if the drawing should be sketched in $\frac{1}{2500}$ scale of the natural the curve radius on the curve scale is indicated with 52·5 cm., the dius of the curve will be 52·5 × 2,500 = 131,250 cm., or 1,312·5 meters; ld the drawing be sketched in $\frac{1}{500}$ scale, and the curve scale indicates he radius of the curve will be 43 × 500 = 21,500 cm., or 215 meters.
urve scale can likewise be used as a reduction scale of every other which is to be calculated in meter measure, as the radius in meters ys be read directly, no matter in what scale the drawing is made.
a great saving of labour, which is very much facilitated if, as often e, old maps and drawings are to be made use of.
g the curve scale it will sometimes happen that the curve to be ed does not exactly meet the line drawn on the scale, but will fall two lines. In this case the smaller division can, as the radii are progressively by 0·5 cm., be easily estimated with the naked eye after practice.
xample, the curve of the radius of 1,110 meters, at a proportionate $\frac{1}{2500}$, lies between 88·5 and 89·0 of the curve scale, and amounts to ·9.
wever, in most cases, round numbers, without fractions, are chosen dii, the radius can always be determined with the greatest accuracy.

Calliper Apparatus, for accurately determining dia- and lengths up to 150 mm.

A. Meissner (H. Müller and F. Reinecke), Berlin.

alliper apparatus is to be employed for the exact determination of rs and lengths, as far as 150 millimeters; the $\frac{4}{1000}$ part of a milli- y estimation, and $\frac{1}{25}$ millimeter by direct reading by means of a ope.

for the use of

F. W. von Gehren, Giessen.

in use for the purpose ... by many ... added to the collection.

... with ... lever.

... University of Kiel (Prof. Dr.

... Science Institute ... and made use ... of the archives

... Von Moore ... Physik" p. 306 and

... Thickness of Thin ...

E. Fuess, Berlin.

... among most of ... for determining

... apparatus designed ... particularly

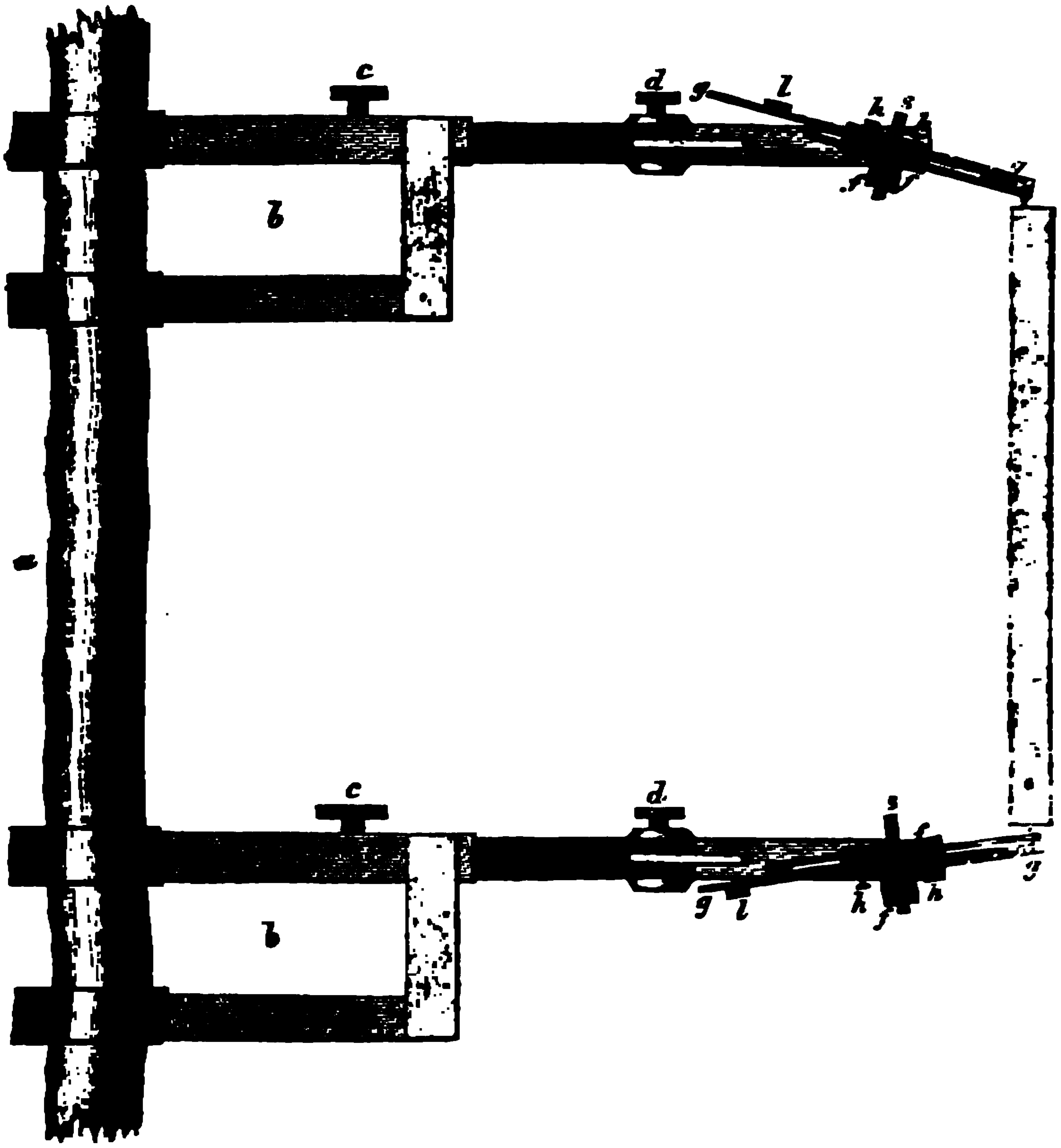
University of Gratz.

... reading by reflection from ... these perpendi- ... be measured as ... are placed, at some ... reflected by the mirror ... position of the point at ... indicated by the quotient, ... the mirror from the ... axis of rotation.

... in the apparatus, ... placed at any distance ... a shifting of the ... movement of the end- ... As, however, the ... the reading

... reading with this apparatus ... and powerful

... that surface must be ... as well as to the part ... that surfaces the levers are



The arrangement of the apparatus is as follows :—

In a solid brass pedestal, which rests on three adjusting screws, there is cemented a strong glass tube *a*, $1\frac{1}{4}$ meter long, to which two brass bars *b* are affixed. Each of these brass bars consists of two parts, of which the one moves or slides in the other in such a manner that it can be either lengthened or shortened. The screw *c* serves for fixing the chosen length. By means of the joint *d* a horizontal rotatory or veering movement of the fore-part of the bar can be effected. Close to its free end there is on each side a steel point—the two forming together an axis—which is held by a bow *ff* carrying two pins, in such a manner that the bow can be easily but surely turned round this axis.

The lever *gg* which must be firmly connected with the bow, has longitudinally a slit, or slide, with two sliding pegs placed in a level position with the axis and fastened to the bow, along which the lever can be moved, so that at whatever distance from the axis the extreme end of the lever may be fixed the lever must always turn with the bow around the axis.

In order not to be obliged to take the measurement of the length of the lever afresh at each experiment, the lever is provided at its upper surface with conical-shaped cavities in which the screws *hh* catch. These conical-shaped cavities would be, properly speaking, visible only in a drawing of a

in length, and divided throughout into millimeters, is inlaid into the prism. Sliding along the same is a telescope, likewise fitted with a cylindrical water-level, the supporter of which is provided with a nonius indicating $\frac{1}{20}$ mm. Added to the same is—

Water-level, for regulating the direction of the prism.

310. Cathetometer, so arranged as to be used as horizontal measure; can be unscrewed. *Prof. Dr. Dove, Berlin.*

311. Cathetometer, by Breithaupt and Son, in Cassel, with riding level. *Polytechnic School in Cassel (Dr. E. Gerland).*

1. The following improvements, contributing partly to more minute indications of the apparatus, partly allowing the correction of the several parts the one to the other, have been added to the well-known construction of cathetometers.

The firmly placed central axis, around which the long case with prism turns, can be placed vertically by a special cylindrical water-level, indicating 10 minutes; the latter is therefore fastened to that case independently of other parts, in order that the vertical position of the axis required at very fine measurements can be easily observed; the more so, as all other examinations are based on the correct adjustment of this water-level. The vertical position of the axis is effected in the same manner as with an ordinary levelling instrument, and any deviations of the water-level are corrected half on the correction screw of the same, and half by the regulating screws of the tripod.

The prism, the inlaid silver scale of which, of 1 meter in length, is throughout divided into millimeters, and fitted with a vernier for $\frac{1}{20}$ mm., can be placed in a perpendicular and a horizontal position towards the axis of revolution. For this purpose a specially constructed attaching or adjusting water-level, which is fastened to a right angle, and can be turned, is placed on the face, and the edges of the prism, and thereby the latter, which has at the sides and behind regulating screws for that purpose, is corrected as required; at this correction it is necessary to pay particular attention, by means of water-level attached to it, to the exact perpendicular position of the axis of revolution.

After the telescope water-level has been previously examined by reversion and adjusted, the rectangular position of the telescope towards the prism is effected by screws, which allow a slight raising or lowering of the telescope supporter. If this is done, the bubble of the telescope water-level will remain unchangeably in the centre at the turning of the whole instrument around its central axis, as well as at the upward and downward motion of the shifter.

A very severe proof consists in sighting with the telescope a distant object, the telescope being reversed in its sockets, and the apparatus turned round 180°, at which manipulation the former object must be intersected again by the ocular cross what must always be the case with an exactly constructed and well rectified instrument.

The unalterable cross in the ocular is cut in glass, in order to prevent hygroscopical and other interruptions. For the purpose of obtaining the rectangular position of the telescope, the supporter may also be placed with one end between points, while an elevation screw is fixed to the other. The essential point for effecting the before-mentioned correction by employing the attaching or adjusting water-level consists simply in adjusting the water-level axis exactly to the leaning face by means of the correction arrangement marked *a* in the drawing. The proof is effected by reversing the angle

vertically, the water-level turning thereby between its points. If after the proper attachment the bubble deviates from the centre, half of this deviation will be corrected by the regulating screws of the tripod, and the other by the said correction arrangement *a*. It is, however, to be mentioned that *previous* to the above proof the parallel position of the water-level axis towards its points of attachment is to be examined, which can effected by reversing between its two points, and thereby a deviation of the bubble, if there be any, will be removed half by the adjusting screw *b*, and the other half by the arrangement *a*. Finally, there remains the examination and correction of the water-level sideways to be made, which is done in the usual manner by the screw *c*. This attaching or adjusting water-level may also be recommended for other purposes, for instance, in mounting of machines, &c.

Regarding the peculiar construction of the aforesaid adjusting water-level, the suspension between two points, in general, it may be remarked that the same has been derived from the compensation-level constructed by F. W. Breithaupt and Son some years ago (vide Dingler's Polytechn. Journal, vol. CLIV. p. 401). In what manner this principle has been adopted by other mechanical workshops, and represented partly as an invention of their own, has been proved by an article in this Repertorium, vol. IX., p. 127, by the addition of an arrangement or simplification totally at variance with the construction.

E. Dividing Engines.

248. Instrument for **dividing Mathematical Scales** or **Rules.**

Lent from the Patent Office Museum by the Commissioners of Patents.

This instrument is to be used for dividing scales according to the French, Swiss, or English measures of length, and is provided with a vernier for obtaining the smaller divisions of the scale. It can also be adapted for producing diagonal scales.

265. Machine for **dividing right lines,** by Nicholas Fortin.

MM. Fortin Hermann Bros., Paris.

This machine is that constructed by the celebrated inventor in 1787, and used in the works connected with the adoption of the metrical system.

The pitch of the screw is exactly one millimetre. (Fortin's machine for dividing circles, as well as this machine, was presented to the Conservatoire des Arts et Métiers by MM. Fortin Hermann Bros., in 1876.)

297. Micrometer Dividing Machine.

Voigt and Hochgesang (Gust. Voigt), Göttingen.

The screw of the dividing machine has a rising gradient of $\frac{1}{4}$ mm. to 0·25 mm. The top of the same is divided into 200 parts; each part, therefore, corresponds to $\frac{1}{800}$ millimeters. The nonius supplies a reading of $\frac{1}{10}$ of this value. By a spring fixed in the inside of the prism the dead movement of the screw will be completely removed.

The tracing appliance is constructed in the simplest manner possible. The tracing point—a diamond—is lifted by a mechanical contrivance, and let down again.

The sledge allows of drawing a line of 30 millimeters in length.

For constructing *ocular micrometers* there is an arrangement making three linear lengths in a mechanical manner.

1

2

2

1
ar
stru
mo
inc
con
for
T
don
the
fatig
bein
A
erec
ture
may
of th
T
gam
Th
dvis
the
ase
atio
less
retai
stret

and fro by the rising and falling water, and by the , and may be read off at any desired intervals of

is necessary of the mean water-level (the true level ations of the registering apparatus is saved by the ical arrangement, and effected automatically with e tide-measurer.

ing Tide-gauge, improved.
H. C. Ahrbecker.

le of the paper can always be seen, and requires h. The clock goes for 32 days.

phe," or tide-gauge. *Van Rysselberghe.*

OUS LENGTH-MEASURING INSTRUMENTS.

Wheel for determining distance by regis- revolutions ; the upper index pointing out wer every 100 revolutions.
Elliott Brothers.

or Way Measurer in gilt metal case early example probably made in the second y.
Alexander Nesbitt.

of Inventions is a description of two instruments nged to the Emperor Rudolph II. (1576–1612).

Measuring Wheel or Mile Meter.
Elliott Brothers.

grammeter. This instrument is specially the ordinates of indicator-diagrams 5″ long, r the manner of a parallel rule, the register- being first placed at zero ; when it is required nent the key for break is depressed, and when have been taken the distance the nut has an ordinate.
Henry P. Holt, C.E.

er (by Salleron), to read to ·001 mm.
l of the Yorkshire College of Science, Leeds.

emefna.—A pendant for the watch-chain.
's Patents Engineering Works, Birmingham.

ely necessary to advance the Wealemefna over the and will register the inches and fractions of an inch, et. The instrument registers to 25 feet.

g Instrument, for the use of architects, contractors, timber merchants, &c. &c., and g purposes, in place of the rule or tape.
is Patents Engineering Works, Birmingham.

To use the instrument it is merely necessary to advance it along the object to be measured, when the large hand will register the inches and fractions of an inch on the outer dial, the smaller hand on the inner dial, the feet and the smallest hand on the recessed dial, the tens of feet travelled over. The instrument registers to 100 feet. Price, electro-silver, in leather case, 16s. 6d.

277a. Pedometer, of the latest and most approved form.
J. and W. E. Archbutt, Westminster.

This instrument has pendulum action, and is worn suspended in the waistcoat pocket; it is provided with a regulator whereby it can be set to most accurately record distances walked.

277b. Improved form of Pedometer, by Dolland, in which the direct chain action is substituted for the lever made in the early part of the nineteenth century.
J. and W. E. Archbutt, Westminster.

277c. Pedometer or instrument for accurately registering distances walked. This instrument was invented and made by Spencer and Perkins in the latter part of the eighteenth century. *J. and W. E. Archbutt, Westminster.*

278. The Chartometer. E. Russell Morris's patent. (Silver Medal, awarded at Manchester, 1875.)
The Morris Patents Engineering Works, Birmingham.

The only instrument that measures and registers distances on maps, plans, scaled drawings, &c., and that is adapted for various scales. By guiding the small steel wheel along any route on a map, the hand registers the actual distance in miles, yards, &c., according to the dial in use and the scale of the map, which should correspond. To deal with a map of a difficult scale, the glass front is opened by pressing a spring; the dial removed, and another corresponding to the fresh scale slipped into its place. A set of dials adapted to the scales of all the Ordnance maps, and the usual scales of travelling maps, &c., &c., is contained in a recess of the leather case, beneath the instrument.

290. Scale for Measuring Curves. Eschenauer's patent.
Hermann Schäfer, Darmstadt.

1093a. Ellipsometer.

Before the eye-piece of the glass, a double refracting prism is made to turn until a wire, moving perpendicularly to the principal section of the prism, gets to pass through the two intersecting points of the two reflections of the ellipse. An index shows at the moment the position of the prism.

III. MEASUREMENT OF AREA.

316. Amsler's Planimeter, for calculating with perfect accuracy the contents of plans, maps, or other plane surfaces, in square inches and metrical measure. *Elliott Brothers.*

17. Polarplanimeter. *A. Ott and G. Coradi, Kempten.*

' means of the polarplanimeter the superficial contents of any kind of s drawn on paper, no matter what their outline may be, can be ascer- l by mere tracing more exactly and quickly than by any other method. e inventors of this instrument are respectively J. Amsler, in Schaffhausen, Ch. Harke, in Vienna. Ott and Coradi's construction is a combination th, embracing the excellences of each. It differs from Amsler's instru- by the pole (axis) of the instrument not being formed by an inserted : of a needle, but by a steel ball embedded in a metal cylinder, thus giving firmer position; and, moreover, by the axis of the roller being lodged in rizontal frame, and the dividing circle of the roller (cylinder) as well as ndicating wheel being free at the top, thereby affording much easier and accurate reading than Amsler's instrument. This arrangement has the ntage that for simple calculation the zero point of the drum can be placed tly on the zero point of the nonius, when the tracing pencil is at the nencemont of the figure. The weight can be separated from the instru- ., by withdrawing the bolt, and placed in the case by itself. The runner ring the axis of the polar arm can be moved along the whole length of the rangular bar, by which means at every agreeable longitudinal scale a d number can be obtained for the value of the nonius unit (for example, 1·500 nonius unit, 2 square meters, or scale 1·1440 nonius unit, 5 square ms). The tracing bar is divided into ½ mm., and the runner sliding on ame carries on one side a nonius, on the other an index. For adjustment the index, the most usual or specially desired longitudinal scales are ed with lines on the bar; by means of the nonius and the divisions on the proportions of measure not previously given can be easily inserted and d down; in the same manner, in the case of plans which have been drawn hrivelled paper, the area can be retained in its actual size by a corre- ding movement of the runner, and the position of the nonius noted down a certain amount of shrivelling.

118. Planimeter, divided on a glass plate, in a case.

F. W. Breithaupt, Cassel.

he planimeter consists of a net marked on a glass plate for a certain tion of the meter measure.

119. Wetli's Planimeter.

Physiological Institute of the University of Halle (Prof. Bernstein, Director).

The planimeter is fitted together by placing the six-toothed movement into e centre of the divided disc, whilst the central point of the small glass disc ves at the other end in the screw of the hoop encircling the divided disc. xt, the sledge with the large glass disc is placed on the three-railed track such a manner that the horizontal glass disc comes underneath the smaller rtical one; the latter is then, by means of the screw which is fixed on the op, regulated in such a manner that it is easily carried along by the hori- ntal disc by friction.

The pointer moving with the same on the same axis on the dividing disc licates by a pencil, easily observable by watching the instrument, the figure cording to its superficial contents in quadratic millimeters. The toothed the wheel contrives a reading of every 1,000 quadratic millimeters of the ed outline of the surface.

IV. MEASUREMENT OF VOLUME.

321. Schmid's New Water Meter. *A. Schmid, Zürich.*

This meter consists of two of Schmid's patent hydraulic motors, coupled at right angles, and enclosed in a water-tight casing. They are set in motion by the force of the fluid they have to measure. At each revolution a volume equal to the contents of four cylinders must pass. The pressure required to keep tight the oscillating surfaces of the cylinders is furnished by the difference of pressure at inlet and outlet, which is thus self-regulating. The meter is also kept in motion by the difference of pressure. The frictional resistance is the same with all pressures of the fluid under measure, and, according to the size of the meter, is represented by a water head of 3 to 16 ft. The different parts of the meter are constructed of materials not liable to chemical influence.

The chief advantages of this meter are:—

1. The velocity of the engine is exactly in proportion to the quantity flowing through the meter.
2. According to the most careful experiments, the error, if any, does not exceed 1 per cent.

321a. Siemens' and Adamson's Patent Water Meter.

Guest and Chrimes, Rotherham.

This meter has a great resemblance to the motive-power machine known as Barker's Mill. The water passes down through a funnel into the measuring drum, and in passing outward through the curvilinear channels of the same causes it to revolve, delivering a certain quantity of water at each revolution of the drum, and this is indicated by worm wheel and gearing, in gallons, feet, or any other measurement required, on a dial plate properly divided and prepared for the purpose.

The meter is exhibited in section, so that the internal arrangements and its action can be seen. This meter has been extensively used for upwards of 20 years.

321b. Half-inch Patent Water Meter, for the water supply for domestic and trade purposes on the constant supply system.

J. Tylor and Sons, London.

322. Measures of Capacity, according to natural principles.

Hans Baumgartner, Basle.

323. Measures of Quantity, according to natural principles.

Hans Baumgartner, Basle.

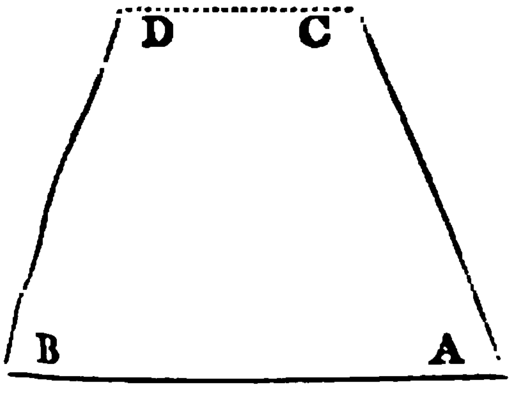
324. The Standard Pint, popularly known as "The Stirling Jug."

The Burgh of Stirling.

This measure was entrusted to the town by Act of (the Scottish) Parliament, in the year 1437. Sometime previous to 1745 it had been borrowed by a coppersmith for the purpose of making others, and as he joined the insurgents in "45" it was lost sight of. On his not returning, his effects were sold, all but a few that were thrown into a garret as rubbish; among these, in 1752, the Stirling Jug was found, after some years of patient and unwearied search (by Rev. A. Bryce, of Kirknewton). It is made of brass, and is in the

hape of a hollow truncated cone, weighing 14 lbs. 10 oz. 1 dr. 18 grs. cottish troy. Diam. of mouth 4.17 English in., of the bottom 5.25 in., and epth 6 in. On the front, near the mouth, is a shield in relief, bearing a on *rampant*, the Scottish national arms, near the bottom is another, bearing a ape *passant gardant*, supposed to be the arms of the foreign maker.

324a. Russian Standard Measures of Capacity (Vedro, V., ½ V., $\frac{1}{10}$ V., $\frac{1}{100}$ V.). *Siemens and Halske, Berlin.*



These measures, made of bronze, have a conical shape, newly adopted in Russia, for standard and trade measures of capacity. In these measures the inner diameter, A B, of the bottom is equal to an inner side, A C, and double diameter, C D, of the orifice. By very simple contrivance, such trade measures might be verified, approximately, by (linear) measurement of A B, A C, and C D.

325. Set of Standard Measures for Alcohol, conical shaped, in order to diminish the possibility of evaporation of the liquid. *Siemens and Halske, Berlin.*

326. Water-meter, for cold water, for 26 mm. width of tube. *Dreyer, Rosenkranz, and Droop, Hanover.*

327. Water-meter, for domestic use. *Dreyer, Rosenkranz, and Droop, Hanover.*

327a. Patent Water Gauge for steam boilers, independent of level or distance. *John Nicholas.*

This instrument is for indicating in an office or ship's cabin the quantity of water in the boiler or other vessel to which it is attached. The boiler may be any distance from the office, and upon any relative level. The small tank represents a portion of a boiler to which the stand pipe is attached; in the centre of the stand pipe is a brass tube, open at the top into the steam space, and communicating at the bottom with the right-hand union. The left-hand union opens directly into the water space. The right-hand union is connected by a lead pipe with the top part of the gauge glass, the other by a similar tube with the bottom of the glass, forming a continuous tube, one end of which is open to the steam and the other to the water space. This system is now entirely filled with water, which will always have the same level inside the brass tube as in the boiler, and any movement in the boiler will cause a corresponding motion in the brass tube, such movement being continuous throughout the system. A small quantity of oil is placed in the gauge to show readily this movement, and the line of contact in the glass tube represents the position of the water in the boiler.

327b. Patent Indicator, for tanks or reservoirs. *John Nicholas.*

This gauge is similar to that last described, but the atmosphere giving comparatively a constant pressure the stand pipe can be dispensed with. The brass tube referred to in the previous description may be seen in the tan

Balance, with 14-inch beam, fitted with agate knife d agate planes, to carry 1,500 grains in each pan, and nctly with ·001 grain. *L. Oertling.*

Balance, with 16-inch beam, fitted with agate knife d agate planes, to carry 2 lbs. in each pan, and turn with ·02 grain. *L. Oertling.*

Balance, with triangular beam, $6\frac{1}{2}$ inches long, fitted te knife edges and agate planes, to carry 3,000 grains, and inctly with ·01 grain. *L. Oertling.*

Balance, with beam $6\frac{1}{2}$ inches long, fitted with agate ges and agate planes, to carry 2,000 grains in each pan, distinctly with ·02 grain. *L. Oertling.*

Portable Assay Balance, with 6-inch beam, to carry s in each pan, and turn distinctly with ·001 grain. *L. Oertling.*

Balance, constructed by H. Olland, of Utrecht, to odies up to 40 kilogrammes. *Prof. Dr. P. L. Rijke, Leyden.*

nstrument is furnished with a double system of "fourchettes," by a rod 0·6 m. long. A difference of 1° in the point of equili- swered to a difference in weight of—

9·5 m. gr.	when the weight was	20	kilogrammes.
10·5	"	50	"
13·8	"	73	"

weights of about 50 kilogrammes, in a series of experiments under e conditions, between each of which the balance was set at rest, not differing in the average by more than 0°·03 were obtained. nditions were less favourable, the differences amounted to 0°·26, and hed 0°·94 when the conditions were altogether unfavourable.

Balance, charge up to 500 grammes in each pan; to $\frac{1}{10}$ part of a milligramme with its full charge. *Beckers Sons, West Zeedyk, Rotterdam.*

balance is furnished with agate knives, and all bearings run on agate it has a rest for pans and beam, and apparatus with adjustable shelf g specific gravities. The beam is divided in $\frac{1}{10}$ part of a milligramme. weights from 500 grammes down to 1 milligramme. Three riders.

Analytical Balance, on plan suggested by Professor r, Anderson's University, Glasgow, for a charge up to mmes in each pan. *Beckers Sons, West Zeedyk, Rotterdam.*

nstrument shows a new method for displacing the centre of gravity of , and for weighing up to 110 milligrammes by means of riders. The form a part of the balance, with plunger for displacing exactly s of water at 15° C. for taking specific gravities of liquids. Sets

343. Balance, with drawer and eccentric for lifting, movable pans, set screws and level, charge up to 1½ kilos. in each pan, sensible for 20 milligrammes with its full charge.
Beckers Sons, West Zeedyk, Rotterdam.

344. Balance, charge up to 1 kilo. in each pan, sensible for 20 milligrammes with its full charge.
Beckers Sons, West Zeedyk, Rotterdam.

346-9. Frerich's analytical **Balance,** capable of carrying 2,000 grms. with rider movements and a set of gramme weights.
F. Sartorius, Göttingen.

350. Analytical **Balance,** capable of carrying 500 grms., and a set of gramme weights. *F. Sartorius, Göttingen.*

351. Analytical **Balance,** capable of carrying 200 grms., with a set of gramme weights. *F. Sartorius, Göttingen.*

352. Frerich's analytical **Balance,** with contrivance of weighing by means of torsion. *F. Sartorius, Göttingen.*

353. A Pair of Russian Scales.
Bennet Woodcroft, F.R.S.

354. Test Balance capable of carrying 20 grammes in each scale. *Edouard Sacré, Brussels.*

The bearings are taken off the knife edges when the balance is at rest. With 20 grammes the balance is affected by the 750th part of a milligramme. With 2 grammes it is affected by the 7,000th part of a milligramme.

357. Printing Beam for Weighing Machine, admitting of the registration of each weighing. *M. Chameroy, Paris.*

This method of checking is applicable to all weighing machines in the nature of the steel-yard. It would be found useful at custom houses, depôts, markets, railway stations, works, and other similar places.

Its advantages are :—

1. The affording of a record, by means of a printed impression on a special ticket, of the exact amount of the weight as determined by the machine itself.
2. The facilitating of the reading of the weights, either on the ticket or the scale beam.
3. The preservation of an exact record of weighings, the authenticity of which is thus ensured.

358. Physical Balance, weighing up to five kilogrammes.
Hugo Schickert, Dresden.

359. Physical Balance, weighing up to 200 kilogrammes.
Hugo Schickert, Dresden.

363. Fine Assay Balance for weighing 20 grammes, turning with 1/100 mg. *G. Westphal, Celle.*

64. Large Balance for determining the specific gravity of ids. *G. Westphal Celle.*

65. Large Balance used in the **Manufacture of Sugar.** *G. Westphal, Celle.*

66. Small Balance for determining the specific gravity of ds. *G. Westphal, Celle.*

67. Pharmaceutical Balance, for simple chemical opera- s. *G. Westphal, Celle.*

70. Balance for chemical and physical purposes. *C. Staudinger and Co. (F. W. von Gehren), Giessen.*

ese three instruments, together with No, 368, and 369 are chiefly used estry and agriculture.

lance of the firm's own construction; capacity of weighing, one kilo- me on each scale; sensibility at this weight, 0·4 milligr. The balance is of one piece of wrought (not cast) brass, and gilded. The centre and nating edges consist of steel, and all supports of hard stone. The weight e beam with edges is = 793 grammes; flexion of the beam at 1 kilogr. it on each scale = 0·14 mm.; at 1,500 kilo. weight = 0·028 mm.; at kil. weight = 0·048 mm. at 3·000 kil. = 0·070 mm. A permanent flexion not been observed at such a weight.

75. Ten Plates of Rock Crystal for Balances. *Hermann Stern, Oberstein.*

176. Chemico-physical Balance, executed by Ch. Jung, Giessen.

Collection of Physical Instruments of the University of Giessen (Prof. Dr. Buff).

y shortening as much as possible the beam (balance) these scales offer advantage of great flexibility and sufficient rigidness to weigh accurately 250 grammes to $\frac{1}{10}$ milligrammes.

177. Analytical-balance, executed by Stollenreuther. *University of Munich.*

179. Standard Weights in Glass, executed by Stollen- ther. *University of Munich.*

81. Model of a Balance for determining the quality of in, adjusted according to the directions of the Imperial German mmission for Standard Weights and Measures, with a corn asure of 1 liter capacity. *Reinhold Löhmann, Berlin.*

e manner of adjusting the several parts, as well as the successive series plications of the same, is illustrated and facilitated by an explanation, sectional and cross-sectional drawings, accompanying the model.

e practical employment and use of the apparatus for scientific and ial industries, in the first instance, and next for the solution of national- mical problems, will be demonstrated by two continuous memoirs, lished by the Imperial Commission for Normal Weights and Measures.

383. Model of a Centesimal Weighing Machine, with glass platform. *Dr. Kohlmann, Halle.*

384. Model of a Decimal Weighing Machine, with glass platform.

Physical Institute of the University of Halle (Prof. Knoblauch, Director).

386. Beam Balance with equal arms, sensibility 1 : 200,000.
Kleemann, Mechanical Engineer, Halle.

390. Beam Balance, for educational purposes.
Alex. Bernstein and Co., Berlin.

The steel-yard, for educational purposes, has contrivances for demonstrating the different peculiarities of a scales-beam, or balance, namely, displacement of the centre of gravity, lifting and grinding of the principal nut, unequal lengths of levers, non-parallelism of the knife edges, and position of *one* terminal knife edge extraneous of the level of the two other knife edges.

388. Small Decimal Balance, for educational purposes.
Alex. Bernstein and Co., Berlin.

The decimal balance for instruction in schools has on each prism a scale so that the influence of the weight of each prism can be shown by itself.

389. Analytical Balance.
Alex. Bernstein and Co., Berlin.

The analytical balance has a capacity of bearing 500 grammes, and when fully weighted a sensibility of $\frac{1}{10}$ mgr.; it has a perforated gilded brass beam with axes of agate and pans with arrangement for releasing all knife-edges, stop balance with pencil, and sliding weights movement.

389a. New Balance for a Laboratory, carrying three kilogrammes in each pan, and turning with five milligrammes.
Deleuil, Paris.

When it is not weighing, the beam is supported free of the knife edge, as in other accurate balances; vessels 25 centimetres in diameter can be placed on the pans, also vessels with long necks, and flasks of 1-2 litres capacity. By the aid of the second pan, the specific gravity of very bulby bodies can be taken.

390a. Self-Acting Balance for Galvanic-plastic purposes. *Alex. Bernstein and Co., Berlin.*

The scales for galvano-plastical purposes is so constructed that the conduction is interrupted by self-action as soon as a precipitate (deposit) of a certain weight has been obtained.

391. Balance for Blow-pipe Experiments, in a case with weights. *Alex. Bernstein and Co., Berlin.*

The scales are for blow-pipe experiments; they have steel axes, pans of agate, two scales of horn, two pairs of gilded little bowls, one bowl with hook for the determination of specific weights, and a set of weights from 1 gr. to 1 centigr. of silver; from 1 centigr. to 1 milligr. of aluminium, and the fraction milligr. of quills.

392. Gold Assay Balance.

Alex. Bernstein and Co., Berlin.

The gold-alloy scales have a bearing capacity of 5 grammes, and are provided with axes of agate and pans, and indicate, when fully weighted, $\frac{1}{20}$ milligr.

B. STEELYARDS.

332. Roman Steelyard or Statera, of bronze. It was found in the year 1855, during building operations at Watermoor, a suburb of Cirencester, Gloucestershire.

Professor A. H. Church.

The beam, which is nearly 17 inches long, may be reversed, and it is consequently divided along both its upper and under edges. When the fulcrum nearer the head of the beam is employed objects can be weighed more than twice as heavy as those which can be accommodated when the beam is suspended by the other hook. To the head of the beam is attached a chain, branching below into two parts, each terminated in bold hooks adapted for grasping soft and bulky articles. This steelyard is a very good example of its kind. The locality which furnished it was the site of the Roman city of Corinium or Durocornovium, which has yielded an immense number of Roman remains, many of which are preserved in the local museum.

378. Balance for Weighing in Vacuo, on von Jolly's principle. *University of Munich.*

383. Model of a Roman Balance, with sliding weight of 75 grammes, and stand.

Physical Institute of the University of Halle (Professor Knoblauch, Director).

C. WEIGHTS.

346. Six Standard Weights derived from the axial standard of length. *Prof. Hennessy, F.R.S.*

One of these weights is equivalent at 15° centigrade to a cube of distilled water whose side is the one hundred millionth part of the earth's polar axis. The others are submultiples of this weight, and the system is suggested in connexion with the axial standard proposed by Professor Hennessy.

360. Physical Weights. *Hugo Schickert, Dresden.*

361. Eight Sets of Weights, for analytical purposes.

G. Westphal, Celle.

The first of these weighs from 1 kilogramme downwards, the second from 500 grammes downwards, the third from 100 grammes, the fourth, fifth, and sixth from 50 grammes, the seventh from 10 grammes, and the eighth from 0·5 grammes downwards.

362. Standard Weights, adjusted and gilt.

G. Westphal, Celle.

These consist of a 1 kilogramme weight, a set of weights weighing from 1 kilogramme downwards, and a set of standard weights with pin adjustment weighing from 500 grammes downwards.

362a. Box of Weights, containing two kilos. and fractions of a kilo. *Deleuil, Paris.*

362a. One Case of Weights and Measures.

Set of weights from 1 kilogramme to 1 milligramme.

Set of weights from 50 grammes to 1 milligramme.

Set of weights from 1,000 grains to $\frac{1}{100}$ grain.

Set of weights for assaying silver, 1,000=1 gramme, in circular ivory box.

Sets of weights of rock crystal (one spherical set), from 50 grammes.

Set of measures from $\frac{1}{2}$ litre down.

Sikes' hydrometer, as supplied to the Honourable Board of Inland Revenue.

Bates' saccharometer, as supplied to the Honourable Board of Inland Revenue.

Set of petroleometers for testing liquids of 650 to 900 specific gravity.

L. Oertling.

362b. Iridio-Platinum Standard Kilogram.

Johnson, Matthey, and Co.

374. Sets of Weights and single Weights from 1 kilogramme, made of rock-crystal; amongst them some which have been examined and marked with an index error by the Imperial Commission for regulating Standard Weights and Measures at Berlin. *Hermann Stern, Oberstein.*

The weights, as well as the measures of quartz or rock-crystal, were many years ago recognised as the best and most correct; but no one has, up to this time, executed them in such a manner as to afford institutions an opportunity of procuring them; which want has now been supplied by the exhibitor.

The other objects of agate are such as are produced by the Oberstein-Idar grinding and polishing mill, and can be employed in different kinds of machinery.

387. Set of Pharmaceutical Weights from 0·01 gramme to 200 grammes (19 pieces).

Kleemann, Mechanical Engineer, Halle.

D. Instruments for determining Specific Gravity.

347. Tangential Balance for measuring the density of liquids and solids by the angle of inclination, read on a divided circle down to two minutes, thus giving the third decimal of specific gravity; made by Oertling, of London.

Prof. Carl Wenzel Zenger, Prague.

355. Hydrostatic Balance, by Ramsden; with **Weights,** by Robinson, presented to the Royal Society by Lady Banks.

Royal Society.

368. Xylometer (cylindrical form), with brass cylinder.

Zimmer Brothers, Stuttgart.

369. Xylometer of Glass, prismatic form.

Zimmer Brothers, Stuttgart.

These instruments are chiefly used in the management of forests, and for agricultural purposes.

The xylometer with brass cylinder (No. 1368), as well as the prism-shaped glass xylometer (No. 6369), are employed for exact scientific examinations, especially for the cubature of irregularly-shaped pieces of wood, and for determining the specific weight of wood.

With apparatus, No. 1369, cuneiform pieces of wood which have been split out from the heart in the direction of the pith rays, and therefore contain proportionate parts of all veins of wood, can be quickly and exactly examined.

With both apparatus it is possible to read on the scale accurately down to 5 cub. centimeter (5 grammes water).

(See " Holzmessekunst," by Prof. Dr. Baur, Hohenheim.)

371. Hydrostatic Indicator Balance for determining the specific gravity of liquids, constructed, according to the directions of the exhibitor by Böhm, and Wiedemann, at Munich.

Prof. Dr. W. von Bezold, Munich.

This balance enables to be read at once the specific weight of the liquid contained in the small cylinder. Care, however, must be taken that the floating body is always entirely immersed in the fluid, and that on the other hand the pointer does not move beyond the division on the arc in the direction towards the negative side. This is the case with liquids whose specific weight is smaller than 1, and only then when the free arm of the scales has been loaded with the heavier counter-weight, in which case the number on the arc indicated by the pointer gives at once the specific weight.

With liquids which are heavier than water the lighter counter-weight II. must be used, and 1 to be added to the number read on the graduated arc.

372. Densimeter of Major Bode's construction, for determining the specific gravity of all sorts of powder.

A. and R. Hahn, Cassel.

The densimeter is the only existing instrument with which the specific weight of all sorts of gunpowder (prismatic powder, powder-cakes, fine and coarse grained powder, &c.), can be easily determined, in quantities of 50 to 250 grammes, with the most perfect accuracy.

It is constructed by Major Bode.

This apparatus consists of a reservoir with bolt, two gutta-percha tubes, and a clamp.

1. The reservoir is formed by a steel capsule, with air tight fitting lid.

By means of the bolt the lid of the steel capsule will be screwed fast on this.

The contents of the reservoir are measured so in the clear that a prismatic powder grain can be easily placed in it.

Lid and steel capsule are vaulted, in order to accelerate the evacuation of the air by pumping.

In the steel capsule there is on the upper part, in the lid on the l
an air-tight fitting cut in cock. The reservoir communicates w
cocks by means of two channels, which, for fine-grained powder, a
by a steel tinplate filter, the holes of which have a width of 0·3 mm.
tubes, 1 and 2, are screwed air-tight on the plugs of the two cock
At the upper ends of both tubes funnels of glass are squeezed in
convenient filling and emptying of the mercury. The shorter tube,
about 600 mm. length, carries in the centre a glass-tube, about 200
divided into millims, and can, just above this tube, be closed ai
means of a screw cramp. The interior diameter of the tube No. 1
9 mm., whilst that of tube No. 2, which is about 2,500 mm. long,
only about 5 mm. The gutta-percha tubes are spun over on the out
Reservoir and tube 1 are fastened in a wooden frame; funnel
wooden lining.

This precaution has been taken for the reason that the temperat
mercury and of the apparatus should be altered as little as possible
operation by the warmth of the hands. By means of two strings,
over rollers fastened in the ceiling of the room, funnel 1 and funne
pulled up or down at pleasure.

As auxiliary apparatus are furthermore required :

1. A thermometer, by means of which, previous, during, and after
in of the mercury, the temperature of the same will be ascertained.

2. A fine pair of scales indicating as much as 0·001 gramme
bearing capacity of 6 kilos. (each scale 3 kilos.)

3. A barometer for determining the pressure of the atmosphe
place of operation.

4. A wooden scale, 1 m. long, with a pointed steel sole, and a
exactly measuring the difference in the level of the mercury meni
two tubes 1 and 2.

Theory of the Densimeter.

Let the weight of the reservoir be, with the tubes screwed off, but
of the connecting piece screwing the capsule and the lid tog
grammes. After the reservoir has been evacuated, and filled with
let the weight of the same be, at $t°$ temperature of the chemic
mercury = T grammes.

Consequently the contents of the reservoir filled by the mercury am

$$I = \frac{T - R}{13{\cdot}59(1 - 0{\cdot}00018\, t°)} \text{ cub. centim.}$$

If now P grammes powder be filled into the reservoir, and the
hausted of air, and thereupon filled again with mercury, the same w
at &° temperature, only T^1 grammes consequently amounts the vo
the P. grammes powder, at $t°$ temperature,

$$V = \frac{T - T' + P}{13{\cdot}59\ (1 - 0{\cdot}00018\, t°)},$$

consequently the specific weight of the powder to be examined

$$\frac{V}{P} = \text{specific weight} = P\,\frac{13{\cdot}59\,(1 - 0{\cdot}00018\, t°)}{T - T^1 + P}.$$

The following examples will serve as illustration :

The specific weight of chemically pure mercury amounts at

0° Cels. = 13·59 ; 10° Cels. = 13·57 19° Cels. = 13·55 ; 27° Cels. = 13
5° Cels. = 13·58 ; 15° Cels. = 13·56 23° Cels. = 13·54.

Example 1.

T = the reservoir filled with mercury weighs at 19° Cels. = 1091·6
R = the empty reservoir - - - - - = 329·6

Q = T − R. Consequently mercury 762·0 grammes.

Consequently contents of the reservoir at 19° Cels.

$$I = \frac{T-R}{13{\cdot}59\,(1-t\,0{\cdot}0018)} = \frac{762{\cdot}0}{13{\cdot}55} = 56{\cdot}236 \text{ cub. centim.}$$

If now 60 grammes (= P) gunpowder is filled into the reservoir, and the remaining space of the same with mercury, we obtain

611·6 grammes ($=T_1$)

Reservoir empty = 329·6
60 grammes powder = 60·0

R + P = 389·6 deducted,

remains Q = 222.0 grammes weight of the mercury filling the intervening space, occupying at 19° Cels.

$$I = \frac{222{\cdot}0}{13{\cdot}55} = 16{\cdot}444 \text{ cub. centim.}$$

Consequently volume of the 60 grammes powder = 56·236 − 16·444
V = 39·792 cub. centims.

$S = \frac{P}{V}$ = consequently specific weight of the 60 grammes gunpowder

$$\frac{60}{39{\cdot}792} = 1{\cdot}507$$

Example 2.

If a powder prism weighs 42·0 grammes at 190° C. weight of reservoir, powder prism and mercury = 808·4 grammes.

Reservoir empty 329·6
42 grammes powder 42·0

371·6

consequently of 808·4
371·6 deducted,

= 436·8 grammes weight of mercury,

or $\frac{436{\cdot}8}{13{\cdot}55} = 32{\cdot}236$ cub. centim. occupied by these 436·8 grammes.

Consequently volume of the 42 grammes weighing powder prism = 56·236 − 32·236 = 24·0 cub. centim.

Thus, specific weight of the powder prism = $\frac{42{\cdot}0}{24{\cdot}0} = 1{\cdot}75$

General Formula.

$$S = \frac{P}{V} = \frac{P}{I - I^1} = \frac{P}{\dfrac{T-R}{13{\cdot}59(1-t\,0{\cdot}0018)} - I^1} \text{ or } I^1 = \frac{Q}{13{\cdot}59\,(1-t^0\,0{\cdot}0018)},$$

$$S = \frac{P\,[13{\cdot}59\,(1-t\,0{\cdot}0018)]}{T-R-Q^1}. \quad \text{Since } Q^1 = T^1 - R - P$$

$$S = \frac{P\,13{\cdot}59\,(1-t\,0{\cdot}0018)}{T-T'+P}$$

[redacted]

The extension of the examples 1 and 2, therefore, is essentially facilitated :

Example 1.

Given P = 60 gr. $t = 19°$ C., consequently 13·59 (1 − 19 − 0·0018) = 13·55

T = 1091·6 grammes, T^1 = 611·6 grammes.

$$\text{Thus } S = \frac{60{\cdot}13{,}55}{540} = 1{\cdot}507$$

Example 2.

Given P = 42 grammes $t = 180°$ C.,

consequently specific weight of mercury = 13·55.

T = 1091·6 T^1 = 808·4

$$\text{Thus } S = \frac{42{\cdot}13{,}55}{325{\cdot}2} = 1{\cdot}75$$

Because the expansion coefficient of the reservoir made of steel is different for changing temperatures from that of the mercury, it will be necessary for determining once for all empirically the weights of Tn for ±0, +5, 10, 15, 20, 25, 30, 35° Cels., to calculate the required cubical contents of the reservoir = Vn, to interpolate them graphically, and to embody them from degree to degree in a table.

Directions for Use of the Densimeter.

The temperature of the mercury is determined and noted before, after, and during the period of operation. For that purpose it is advisable to employ a thermometer composed of a very fine glass tube, which admits of being inserted in the gutta-percha tube No. 1, which has been filled up to the aperture of the funnel.

The mercury in funnel 1 will show, on account of the friction and consequent heating, 1 − 3° more heat than that in funnel 2. This difference is, however, equalised in a very short time.

During the operation the apparatus must only be touched on the wooden lining, in order to avoid as much as possible any variations in the temperature which may be caused by the warmth of the hands. The powder to be tested must be of nearly the same temperature as the mercury to be employed, for which purpose it will be best to keep both before the testing operation for several hours in the same room. The reading of the barometer which indicates the pressure of the atmospheric air must be noted down.

1. *Momentum.*

The two tubes 1 and 2 are screwed air-tight to the reservoir, the two cocks are opened, and the apparatus fastened in the wooden frame with vertical position of the tube No. 1.

Thereupon the funnel T″ is lifted to the level of T′ (upon + 760 mm.), and chemically pure mercury poured into the funnel T″, until both funnels are filled with mercury to a height of about 20 mm. The mercury will then stand 760 mm. high above the (±0) point of the reservoir ; consequently the pressure upon the highest point of the reservoir will be altogether two atmospheres (1 atmosph. pressure corresponding in the mean to 760 mm. mercury height).

Under this pressure the air in the reservoir will for the greatest part be already forced up, and in fact in the direction towards funnel 1.

2. *Momentum.*

Now the cramp screw-piece is attached below the funnel 1, and above the glass tube in the centre of the hose 1 filled with mercury, and the latter shut off

air-tight at a height of about +600 mm. Then funnel 2 is sunk to about 1,000 mm. below the zero point of the reservoir. The mercury level will thereupon sink below the reservoir. In case reservoir and hose 1 were already exhausted of air, the difference of the level of both the mercury menisci will be exactly as much as indicated by the barometer, otherwise the difference will be smaller. All the mercury then flows back from the reservoir, &c. into the funnel 2, for which reason the same must have a sufficiently large space of capacity, and must be sunk carefully, not too quickly. Cock No. 1 is then shut, funnel No. 2 lifted above the zero point of the reservoir, and the latter, which in the most unfavourable case will contain only extremely rarified air, filled by the same; then cock 1 is opened, and the cramp at the hose No. 1, so that the mercury in the funnel No. 1 can rise again. This exhausting of the air is repeated a second time if necessary.

For testing whether the reservoir is entirely or sufficiently exhausted of air, funnel 2 is sunk so far until its mercury level has reached about 400 mm. below the zero point of the reservoir. Now occurs a Toricelli's vacuum in hose 1, and the mercury meniscus is seen in the glass tube.

If there were still air in hose 1, the level-difference in the hoses 1 and 2 will be smaller than the height indicated by the barometer for the day in millimeters. In this case the operation mentioned before is repeated. In all cases will, at the utmost at a position again of funnel 2 at about −440 mm., the difference of the level of both the mercury menisci be smaller by 2−3 mm. than the indication of the barometer for the day. If the difference in the situation of the levels should show itself equal to the height of the barometer, what may be easily ascertained by the scale, if its at the lower end pointed steel sole touches the mercury in funnel 2, by adjusting the slider fastened at the height indicated by barometer at the upper meniscus in the glass tube; the pressure at the upper part of the reservoir will then be—

$$\left.\begin{array}{l}\text{1 atmosph. air pressure}\\ -\text{ 1 atmosph. mercury pressure}\end{array}\right\} = 0\text{ mm.}$$

consequently the reservoir exhausted of air.

But in order to employ a further powerfully-acting means for exhausting the air, so far as this should not have been accomplished already, the funnel 2 is lifted as high as possible up to about $2\frac{1}{2}$, 760 = 1,900 mm., thereby the very small quantity of air still present will be forced into the hose 1 under $2\frac{1}{2}+1=3\frac{1}{2}$ atmospheric pressure, and will ascend either towards the hose 1, or occupy only a small and practically insignificant place, of 0·001 to 0·0001 cub. cent. by shutting off the cocks 1 and 2.

The raising and lowering of hose 1 and 2 is performed by pulling or slackening of the cords running over the rollers fastened into the ceiling of the room.

It may now be supposed that the air is completely exhausted from the reservoir, and that its vacuum is completely filled with mercury. At all events the hydro-static air pump of 0 to 3·5 atmosph. pressure, attached to the apparatus in the simplest manner possible, will act much more powerfully than any other air pump, in which the so-called injurious space in the ventilator of the piston makes it impossible to increase the suction action to 0 atmosph. pressure.

Finally, the two cocks 1 and 2 in the mercury are shut off, the temperature of the latter being determined, the two hoses 1 and 2, which have previously been carefully emptied, are unscrewed, the reservoir cleaned of the mercury globules sticking to it (especially in the parts of the screw and the interior channel-openings of the cocks), and the weight of the reservoir, including bolt, determined with mercury.

VI.—MEASUREMENT OF VELOCITY.

A. Logs and Current Meters.

393. Patent Log. Massey. For measuring speed at sea; in use in H.M. Navy.

Hydrographic Department of the Admiralty.

394. Patent Log. Walker. For measuring speed at sea.

Hydrographic Department of the Admiralty.

396. Current Meter, for measuring the velocity of currents in rivers at different depths. *Elliott Brothers.*

An endless screw on a spindle turns two wheels at the same time, the one recording every revolution of the blades by moving one division; the other indicating every complete revolution of the former.

397. Rery's Current Meter, constructed for measuring the velocity of currents in larger rivers. *Elliott Brothers.*

The spherical boss is so determined that it will displace just as much water, as to weight, as will balance the weight of all the parts which are fixed to the spindle, so as to reduce friction to a minimum. Although the apparatus is covered with glass, it has to be filled, before using it, with pure water to establish similarity of pressure inside and outside. After every experiment the water is removed and the spindle thoroughly dried. This form of current meter was used by Mr. Rery on the survey of the Parana and Uruguay rivers.

397a. Darcy Pilot Gauge or Current Meter, for determining the velocity of streams of water. *Prof. W. C. Unwin.*

The velocity is obtained by a single measurement, and no time observation is required. Used in Darcy and Bazin's researches on the flow of water in pipes and canals.

398. Ramsten's Patent Ship's Log. *Elliott Brothers.*

399. Water Meter, based on the principle of measuring the volume of water by recording its speed. *J. A. Muller, C.E.*

This water meter consists principally of an air and water-tight chamber or vessel, wherein moves a float, carrying two magnets of equal power, and fixed with their dissimilar poles in juxta-position to each other: the whole combination of the float and its spindle, together with the magnets, is made as near as possible equal to the density or specific gravity of water. The water in passing through this measuring vessel is forced to take a rotary motion, by means of a screen or a tongue, being a metal piece, put at a certain distance from the inlet opening, and parallel with and lying along the inner circumference of the measuring vessel. The top cover of the measuring vessel is properly dished out, so as to allow of two small soft iron armatures, fixed to a thin metal arm or needle, to be brought outside the vessel, as near as can be to the poles of the magnets inside; the metal arm or needle is fixed to a light spindle, carrying an archimedean screw, which further gears with the registering parts of the apparatus. It is evident that the water in passing through the measuring vessel, or rather alongside the same, communicates its motion to the water inside the measuring vessel, which motion is also communicated to the float and magnets, and lastly to the needle and worm spindle and further

gearing. It is plain that this meter really registers the true velocity of the water, and taking, moreover, in consideration the lightness of its different parts and the transmission of the speed of the float by means of magnets, it will be found to be a very correct and sensitive meter, of simple and durable construction.

399a. Water-meter, with electrical numbering apparatus, according to Amsler's latest construction. (*See* description.)
Polytechnic School at Aix-la-Chapelle, O. Intze.

If the instrument makes 100 revolutions the electric current will be closed by a contact, and the chime work will be kept in motion during some revolutions of the instrument; it will not be necessary, therefore, in measuring the velocity in water-courses, to pull the instrument out of the water, but only to note the time which passes from one signal to the other. By experiments it must be ascertained what velocities of the current of the water correspond to certain intervals of time of the electric signals.

400. Patent Electric Velocimeter, invented by Francis Pastorelli, arranged for water currents, and for ascertaining the speed of vessels, or rate of their motion through water. It consists of three parts.
Francis Pastorelli.

1. Four hemispherical cups are fixed to the end of four strong metal arms (at a distance of 90° apart) that radiate from a central boss, which are mounted on a horizontal axis at right angles in a framework of metal, or other material, so that they may freely revolve when placed in the water. The horizontal axis has fixed to it a point or piece of platina; upon this work pressing points or surfaces, which can be made of any form, circular or otherwise; each revolution of the axis causes a contact to be made.
2. The same receiving instrument, as used for the mining instrument.
3. A Leclanché battery, as used for the mining instrument.

The receiving instrument can be placed in any convenient position on board.

N.B.—No. 1. This part of the instrument is intended to be fixed at any desirable and convenient part of the vessel, or it may be arranged to throw overboard; under such conditions it will give more accurate indications than the logs now in use, for it is not affected like them in their motion by depth, or the increasing density of water; assuming that corrections be applied for force and direction of currents, with respect to the course or line of motion, I think the errors would not be found to exceed 5 per cent.

402. Apparatus for indicating the **Speed** of a **Ship** by the aid of **Electricity.**
Bennet Woodcroft, F.R.S.

409. A Rhysimeter, without frictional parts, for measuring the speed of water or other liquids whether in pipes or open channels.
Alfred E. Fletcher, Liverpool.

B. Anemometers.

408. An Anemometer, without frictional parts, suited to measure the speed of air or gases, even when highly heated, or when contaminated with smoke or corrosive vapours. Used by H.M. Inspectors of Alkali Works.
Alfred E. Fletcher, Liverpool.

410. Lowne's Portable Air Meter, originally introduced by Casella. *R. M. Lowne.*

The indications of this instrument are obtained by means of a light fan which communicates motion to indicating wheels; the dial of the instrument is placed at right angles to the fan, and is supported by three pillars on a base, which also supports the tube containing the fan. The works are extremely sensitive, the first centres running in jewels, and the indicating parts can be thrown in or out of gear with the fan.

410a. Lowne's Patent Magnetic Anemometer, especially adapted for measuring currents of air, gases, and fluids in positions where delicate instruments would be subject to corrosion. *R. M. Lowne.*

The peculiarity of this instrument is, that the registering works are enclosed in an air-tight chamber, the connexion of the revolving fans with the works being made through a sheet of brass by magnetism. The fans carry a small bar magnet, and the first wheel of the indicating mechanism carries a piece of soft iron, so that when the fans revolve outside the plate of brass the soft iron revolves within by attraction and thereby moves the works.

410b. Lowne's Patent Colliery Air Meter, constructed expressly for use in mines. *R. M. Lowne.*

The external aspect and form of this instrument is that of the well known "Byron's Anemometer." The improvements consist of.—1st, a strong, light, and anti-corrosive fan; 2nd, a large clear dial; 3rd, the indicating parts are perfectly protected from dust and smoke, this being done by a practical mechanical arrangement; and 4th, a lever is placed in a convenient position to enable the observer to throw the indicating wheels in or out of gear with the fan.

410c. Lowne's Patent Magnetic Anemometer and Current Meter, for measurement of velocity of currents of air, gas, and fluids. *R. M. Lowne.*

In this instrument the registering works are enclosed in an air-tight chamber, the connexion of the revolving fans with the works being made through a sheet of brass by magnetism. Gymbals accompany this instrument, with direction vane, for use on board ship.

410d. Lowne's Patent Ventilation Anemometer, originally introduced by Stanley. *R. M. Lowne.*

This instrument measures the air by means of a fan wheel placed in a clear opening, without any obstruction from the registering apparatus, which is in a separate chamber on the same plane as the fans, so that the instrument is quite flat for the pocket; the whole of the works are of extreme sensitiveness, and the axes of the fans run in jewels, the indicating hands give the current that passes the fans in feet (after correction), and a lever above the dial throws the registering works in or out of gear with the fans.

410e. Mining Anemometer, for showing the velocity of currents in mines. *Elliott Brothers.*

410f. Biram's Anemometer. Improved for Coal Mines. *Francis Pastorelli.*

It consists of a broad brass ring; fixed to it is a metal frame which carries three divided circles; in the interior and centre of the ring is a spindle which carries eight vanes; on one end is an endless screw; this works a series of wheels, which give motion to the hands on the dials, which record the velocity of the air current every foot up to 100, 1,000 and 10,000 feet.

410g. Dickinson's Anemometer.

Joseph Casartelli, Manchester.

This anemometer consists of a fan, or plate, made of light material, suspended in a frame on delicate centres, having a balance weight attached to the top of the fan. To one side of the frame is fixed on pivots a quadrant opening out at right angles to the fan, and on it is marked the velocity of the current in feet per minute, as indicated by the angular rise of the fan upon which the current impinges. The advantage of the instrument consists in the fact that *it requires no timing* as required by every other instrument, and from actual experiment it is found as accurate as the most delicate instrument, and very convenient.

410h. Improved Biram's Anemometer.

Joseph Casartelli.

The improvement in this instrument consists in the fan being made of light material, thus greatly diminishing the friction, and rendering it a delicate and useful instrument.

410i. Biram's Patent Anemometer for ascertaining the current of air in mines, air flues, &c.

John Davis and Son.

This anemometer registers up to 1,000 feet. At the bottom there is a tube in which a stick may be inserted, so that the experimenter can stand at a distance from the instrument, otherwise the current of air would be deflected by the body of the experimenter.

The vanes may at will be disconnected from the indices by means of a stud at the side, thus rendering the process of timing more simple and exact.

410k. Biram's Patent Anemometer for ascertaining the current of air in mines, air flues, &c.

John Davis and Son.

The 4″ anemometer indicates up to 10 million feet. The size and angle of the vanes are calculated by mathematics and corrected by experiment, each instrument being corrected separately.

The registering apparatus consists in the 4 in. new anemometer of six small circles, marked respectively X, C, M, X M, C M, and M, the divisions on which denote units of the denominations of the respective circles; in other words, the X index in one revolution passes over its ten divisions and registers 10 × 10 or 100 ft.; the C index in the same way 1,000 ft.; and so on up to 10,000,000 ft.; so that an observer has only to record the position of the several indices at the first observation (by writing the lowest of the two figures on the respective circles between which the index points in their proper order), and deduct the amount from their position at their second observation, to ascertain the velocity of the air which has passed during the interval; this multiplied by the area in feet of the passage where the instrument is placed, will show the number of cubic feet which has passed during the same period.

The novelty in this anemometer is in its extreme portability and substantial workmanship; it is supplied with a lever which disconnects, at will, the vanes from the indices, thus rendering the process of timing more simple.

414. Edelmann's Anemometer with galvanic register.
M. Th. Edelmann, Munich.

416. Anemometer for determining the velocity of the air, and other gaseous currents in pipes and canals.
Moritz Gerstenhöfer, Freiberg.

C. CHRONOGRAPHS.

401. Apparatus for measuring the velocity of projectiles, and capable of recording several measures or lengths on one and the same trajectory and of the same projectile.
Antoine Joseph Gérard, Liége.

403. Ballistic Apparatus Chronoscope, with two pendulums, for ascertaining the speed of a projectile at any point of its trajectory, by measuring the time of direction of a portion of the trajectory; also for measuring portions of time between one tenth of a second and 25 seconds. *Lieutenant-General Leurs, Brussels.*

404. Electric Chronograph, for measuring the initial velocity of projectiles (space required, 0.50 square centimètres on the ground). *Le Boulengé, Liége.*

405. Electric Clepsydra, for measuring the period of time of the trajectory of projectiles (space required, 0.50 square centimètres on a table). *Le Boulengé, Liége.*

405a. Electro-Ballistic Apparatus, for determining the velocity of a projectile, with description of experiments and additional apparatus. *M. Navez, Paris.*

406. Electric Chronograph for the measurement of minute portions of time, &c. &c. *Lieut. H. Watkin, R.A.*

This instrument consists of two upright cylinders resting on a base of wood; between them, suspended by an electro-magnet, is a weight with projecting arms. The cylinder being connected with the secondary circuit of an induction coil, the circuit is complete with the exception of the small spaces on either side of the weight. When taking velocities of shot, the primary circuit is led through screens, constructed so that the current is broken and immediately made again during the passage of the shot. The gun being fired, the weights begin to descend; the shot in passing the first screen causes a spark to flash from one cylinder to the other through the weight; then having been previously smoked register of a white spot the position of the weight at that instant. As the weight continues to descend the same result is obtained at the next screen, &c. &c. Adjacent to the cylinder is a time scale divided into thousandths of a second, subdivided by a novel vernier into hundred thousandths of a second, by which the absolute time taken by the shot between the screens is easily read off.

407. The Clock-Chronograph, contrived for the purpose of measuring the time occupied by projectiles in passing over a

[redacted]

succession of equal spaces, with a view to determine accurately the resistance of the air to their motion. *Rev. F. Bashforth.*

If the fly-wheel be spun by hand, and the markers be brought down, they will trace two uniform spirals on the cylinder; each marker is, however, under the control of an electro-magnet. When the galvanic current is interrupted, a record is made by the corresponding marker being suddenly drawn aside. The circuit of the lower electro-magnet is interrupted once a second by a clock beating half-seconds, which gives a scale of time. The circuit of the upper electro-magnet passes along the tops of all the screens, as is shown in the case of one screen. When one or more threads are broken in any screen, a record is made on the cylinder. Thus, when an experiment is to be made, the fly-wheel is spun briskly by hand, the markers are brought down, and the gun is fired. The times of passing the screens are recorded on one spiral, opposite a scale of time on the other. This instrument was used in making all the experiments referred to in "Reports on "Experiments made with the Bashforth Chronograph to determine the "Resistance of the Air to the Motion of Projectiles, 1865–1870," published by authority. Generally 10 screens were placed at intervals of 150 feet, but in the experiments with the Whitworth gun (p. 162), 16 screens were placed at intervals of 75 feet; some of these records are shown. For a full description of the chronograph, see Proceedings of the Royal Artillery Institution, Woolwich, for 1866, which description is also published separately.

407a. Chronograph for projectile experiments with the recording apparatus of Deprez. *Dumoulin Froment, Paris.*

411. Complete Apparatus for measuring the Velocity of Projectiles in the bore of a gun, and for measuring the speed of electricity. *Siemens and Halske.*

412. Vibration Chronograph, for measuring the time of descent on an inclined plane, executed according to Beetz, by M. Th. Edelmann, at Munich. (A description accompanies the object.) *Prof. Dr. Beetz, Munich.*

413. Edelmann's Apparatus for the descent of a falling Body accessory to Beetz's chronograph. *M. Th. Edelmann, Munich.*

D. Strophometers.

395. Hearson's Patent Strophometer or Revolution Indicator, an instrument for showing at a glance, by the position of a pointer on a graduated dial, the number of revolutions per minute an engine is at the time making. *Elliott Brothers.*

415. Mercurial Gyrometer, or "orbit meter."
Royal Polytechnic Academy (Prof. Reuleaux, Director), Berlin.

The instrument indicates directly the angular velocity of an axle, shaft, &c., in figures showing the rotations per minute. The reading takes place on an alcohol column, which shows on one side a millimeter scale, and on the other the rotation numbers. The instrument is so arranged that the scale of the rotations has uniform graduation.

415a. Revolution Indicator, to show the rate at which machinery is working. *Frederick Guthrie, F.R.S.*

From the machinery an up-and-down motion is communicated to a piston of a pneumatic forcing pump. The compressed air escapes through a fine opening, and also exercises pressure on oil, water, or mercury, in a vessel provided with a manometer tube. The height of the liquid in the tube measures the rate at which the pump and machinery are working.

VII.—MEASUREMENT OF MOMENTUM.

417. Model of the Ballistic Pendulum, erected in the Royal Arsenal in 1814, and transferred to the Royal Military Repository in 1836. Weight, 7,740 lbs. Centre of gravity below centre of suspension 10·97 ft.; centre of oscillation below centre of suspension 11·88 ft. Scale ⅛th. *Major M. L. Taylor, R.A.*

418. Navy Electro-Ballistic Apparatus.
Major M. L. Taylor, R.A.

419. Model of Ballistic and Gun Pendulum, as erected at Shoeburyness in 1858. Oscillating system of gun pendulum, weighs 37 lbs. 10·5 oz.; that of the block pendulum weighs 31 lbs. 8·25 oz. Scale, ⅛th. *Major M. L. Taylor, R.A.*

419a. Spring Balance, with arrangement for suspending the lever and the scales on steel springs.
Physical Institute of the University of Halle (Prof. Knoblauch, Director).

VIII.—MEASUREMENT OF FORCE.

420. Cement Testing Apparatus, for ascertaining the tearing strain of Portland and other cements, in sections of 1½ square inches. Originally designed for the Metropolitan Board of Works. **Press** for removing bricks from mould; and **Moulds** for making test bricks. *Patrick Adie.*

420a. Michele's Patent Cement Testing Machine.
De Michele, Rochester.

The block to be tested is placed in the jaws prepared to receive it, the handle is then turned, which raises the weighted lever by exerting a pull on its short end through the medium of the cement block. When the leverage is so increased as to exert a force too great for the cement to sustain, it breaks, and the lever falls, leaving the main-pointer at the spot to which it had been raised. The arc along which the pointer moves is graduated to show the number of pounds of tensile strain applied. A suitable arrangement, when

the cement block breaks, prevents the lever from falling more than half an inch.

These machines are now in general use, nearly one hundred of them having been sent to different parts of the world. They are principally used by the leading royal and civil engineers in this country, and by a large number of contractors and cement manufacturers.

420b. Drawings of Machines and Apparatus for testing Materials. *Charles Jenny, Vienna.*

Five sheets of drawings, representing :—

1. Machine for testing, by means of traction and pressure, the elasticity and density (solidity) of materials.

The actual machine of the Imperial Institute was constructed by C. Paff in Vienna.

2. Testing machine for materials. Werder's system constructed for testing flexible elasticity and solidity. Executed by the Machine Factory Company, Kell & Co., at Nuremberg.
3. Testing machine for materials. Werder's system. Constructed for testing the elasticity of twisting and solidity. Executed by the Machine Factory Company, Kless & Co., at Nuremberg.
4. Machine and apparatus for ascertaining and determining the elasticity and solidity of wire, leather straps, thin ropes, &c.

Executed in the former workshops of the Imperial and Royal Polytechnic Institute.

5. Optical apparatus for determining the modulus and the limits of elasticity by the application of tractive force, pressure, flexible elasticity, and solidity.

The original apparatus of the Imperial Polytechnic Institute were constructed by G. Starke and Kammerer, mechanicians, at Vienna.

421a. An Attraction Meter. An instrument for measuring horizontal attraction. *Dr. Siemens.*

This instrument consists of two horizontal tubes of wrought iron, terminating at each end in a horizontal tube of cast iron. The first-named horizontal tubes are partially closed at their extremities, and communicate with the transverse tubes below their horizontal mid-section. The transverse tubes communicate also by means of a horizontal glass tube of 2 millims. diameter at a superior level to the former.

The whole apparatus being mounted upon three set screws is filled to the level of the half diameter of the transverse tubes with mercury, which mercury also fills the whole of the longitudinal connecting tube ; the upper halves of the cast-iron transverse tubes and the glass connecting tube are filled with alcohol, comprising, however, a small bubble of air, which can be made to occupy a central position in the glass tube by raising or lowering the set screws.

If a weighty object is approached to either extremity of the connecting tube, an attractive influence will be exercised upon the mercury, tending to a rise of level in the reservoir near at hand, at the expense of the more distant reservoir ; and this disturbance of level between the two reservoirs must exercise a corresponding effect upon the index of air in the horizontal glass tube, moving it away from the source of attraction. The amount of this movement must be proportional to the attractive force thus exercised. Variations of temperature have no effect upon this instrument, because the liquids contained on either side of the bubble of air are precisely the same in amount ; and the total expansion of the liquids is compensated for by an

open stand tube rising up from the centre of the connecting tube through which the apparatus can be easily filled.

It is suggested that an instrument of this description may be employed usefully for measuring and recording the attractive influences of the sun and moon which give rise to the tides.

The instrument, which is of simple construction and not liable to derangement from any cause, would have to be placed upon a solid foundation with its connecting tube pointing east and west, records being taken either by noting the position of the index upon the graduated scale below, or by means of a self-recording arrangement through photography.

421b. The Bathometer. An instrument for measuring the depth of the sea without the use of the sounding line.

Dr. Siemens.

The total gravitation of the earth, as measured on its normal surface, is composed of the separate attractions of all its parts, and the attractive influence of each equal volume varies directly as its density, and inversely as the square of its distance from the point of measurement.

The density of sea water being about 1·026, and that of the solid constituents composing the crust of the earth about 2·763 (this being the mean density of mountain limestone, granite, basalt, slate, and sandstone), it follows that an intervening depth of sea water must exercise a sensible influence upon total gravitation if measured on the surface of the sea.

The bathometer consists essentially of a vertical column of mercury contained in a steel tube having cup-like extensions at both extremities, so as to increase the terminal area of the mercury. The lower cup is closed by means of a corrugated diaphragm of steel plate, and the weight of the column of mercury is balanced in the centre of the diaphragm by the elastic force derived from carefully tempered spiral steel springs of the same length as the column of mercury.

One of the peculiarities of this mechanical arrangement is, that it is parathermal, the diminishing elastic force of the springs with rise of temperature being compensated by a similar decrease of potential of the mercury column, which decrease depends upon the proportions given to the areas of the steel tube and its cup-like extensions.

The instrument is suspended a short distance above its centre of gravity in a universal joint, in order to cause it to retain its vertical position, notwithstanding the motion of the vessel, and vertical oscillations of the mercury are almost entirely prevented by a local contraction of the mercury column to a very small orifice. The reading of the instrument is effected by means of a glass tube on the top, which connects the upper surface of the mercury with a liquid of less density, the terminal extremity of which on a scale represents the depth.

Variations of atmospheric pressure have no effect upon the reading of this instrument; but a correction has to be made for variations of atmospheric density as affecting the relative weight of the mercury column, which correction might be avoided, however, in excluding the atmosphere.

From both the upper and lower surface of the mercury, and connecting the extremities of the column, the only necessary correction is that for the effects of latitude, which may be calculated as depths in fathoms, and tabulated for use with the instrument.

The readings of the instrument have been checked by actual soundings taken by means of Sir William Thomson's steel wire sounding apparatus; and the comparable results agree in all cases as closely as could be expected, considering that the sounding line gives the depth immediately below the

vessel, whereas the bathometer gives the mean depths taken over a certain area, depending for extent upon the depth itself.

It is thought that the bathometer may render useful service to the mariner in warning him of changes of depth long before reaching dangerous ground; and the position of a vessel, when no astronomical observations can be taken, may be ascertained by means of a bathometer, provided the contour lines of equal depths of oceanic basins were accurately laid down.

421c. Graphical Bathometer, after von Jolly.

University of Munich.

423. Apparatus for determining the **elasticity, strength of traction,** and **columnal strength** of woods and timber.

Prof. Dr. Nördlinger, Stuttgart.

423a. Apparatus used for experimenting on the Flexural and Torsional Rigidity of Solids, by Professor Everett, and described in the "Transactions of the Royal Society," 1866, p. 185. *Sir William Thomson.*

424. Apparatus for determining the relative **strength of flexure,** and the **elasticity** of woods and timber.

Prof. Dr. Nördlinger, Stuttgart.

425. Hydrostatic Apparatus for ascertaining the specific weight of woods. *Prof. Dr. Nördlinger, Stuttgart.*

425a. Registering Statical Gauge for Pressure in Guns. System of W. Paschkiéwitsh.

Captain W. Paschkiéwitsh, St. Petersburg.

426. Thurston's Testing Machine, invented by Professor Thurston, of Steven's Institute of Technology, Hoboken, U.S.A.

This machine is used for testing the limit of resistance, ductility, and homogeneousness of iron, brass, steel, and other materials of construction. By means of an ingenious but simple arrangement, a permanent diagram of the behaviour under varying conditions of the materials can readily be obtained.

W. H. Bailey and Co., Manchester.

426a. Machine for **measuring** the **slipping** between **hard surfaces** rolling in contact. *Prof. Osborne Reynolds.*

This machine was constructed for the purpose of verifying the conclusions of the exhibitor respecting rolling friction, and the existence of a certain amount of slipping between two smooth surfaces of different curvature, or different hardness, when the one rolls on the other under pressure. It has also been used to measure the slipping between the surfaces, when the one is driving the other against various resistances and at various speeds, as well as the wear of the surfaces.

The large rolling surface is of cast-iron, supported so that it can rotate freely, but otherwise rigidly fixed. For the smaller surface various materials have been used, that exhibited being of steel; this cylinder is supported so that while its axis is always parallel to that of the larger cylinder, it can be pressed against the larger cylinder with various degrees of pressure by means of a lever acting through friction rollers. Arrangements are made for recording the number of revolutions of both cylinders; and connected with

both spindles are driving pulleys and friction breaks on Appold's system, by means of which the force to be transmitted can be regulated.

An amount of slipping of not more than the one hundred thousandth part of the distance rolled can be measured with this machine.

The machine was constructed in Owen's College by Mr. Foster.

427. Phroso-dynamic Apparatus for testing wires, by Mr. Alcun. *M. Digeon, Paris.*

428. Von Jolly's Spring-balance.
University of Munich, &c.

428b. Pieces of Steel Cylinders, torn by traction in experiments made to ascertain the influence of mode of treatment on the mechanical properties of steel.
Imperial Technical Society in St. Petersburg.

Annexed is a report on the experiments. Out of a block of unforged soft cast steel were cut, in identical positions parallel to the axis, 16 bars which were treated in heat or forging in eight different manners, two samples in each way. The samples were then turned in shape of cylinders for traction proof, and for each of them determined elastic and permanent elongations for a series of increasing traction forces, density, hardness (by indentation), and other elements. Results indicated in annexed diagrams and tables.

IX.—MEASUREMENT OF WORK.

429. Dynamometer, graduated up to 100 kilogrammes by intervals of 200 grammes, and showing dynams in kilometres up to 981, each interval measuring two dynams nearly in absolute measure. *Prof. Hennessy, Dublin.*

430. Dynamometer graduated up to 10 kilogrammes, and giving absolute dynams in kilogrammetres up to 98, each interval measuring nearly one dynam in absolute measure.
Prof. Hennessy, Dublin.

431. Drawing of a Dynamometrical Apparatus, constructed in 1844 by the exhibitor, to measure the real horse-power of steam-boats. *Prof. Daniel Colladon, Geneva.*

This apparatus, approved by the Academie des Sciences in 1843, was, in the same year, adopted in the Royal Dockyard at Woolwich.

432. Richard's Patent Steam Engine Indicator, with Darke's Patent Detent and Cord Adjuster. *Elliott Brothers.*

By means of the detent, the paper cylinder is instantaneously set in motion or stopped by the movement of the pencil arm, as it is being applied or withdrawn, giving great facilities for taking a number of consecutive diagrams, also rendering its application to oscillating engines much more convenient.

433. Cooper's Patent Slide Valve Indicator. An instrument for ascertaining the relative position between the piston and slide valve of an engine at different points of the stroke.
Elliott Brothers.

434. Flexion Pandynamometer. An instrument designed to determine the work done by a steam engine, by means of the flexion of the beam. *G. A. Hirn.*

On the upper edge of the beam is a rigid wooden bar of the same length, resting in the centre on a fork which prevents it from swerving, fastened to one end of the beam with an iron rod, and free at the other end. To this extremity is attached a non-elastic cord, which passes round a pulley, fixed at the head of the beam, and is carried thence towards the centre, where it is wound round the axis of a very light needle.

It is evident, from this arrangement, that when the beam moves in either direction, the end of the wooden bar which remains rigid approaches to or recedes from the head of the beam. The cord consequently winds itself round, or unwinds itself from, the axis of the needle, and the deviation of the latter indicates the degree of flexion of the beam, multiplied if desired. At the end of the needle is fixed a pencil, which works on a small board placed above the beam. This pencil, at each double stroke of the piston, traces a closed curve, of which the ordinates indicate the successive degrees of flexion of the beam during the work. To graduate, once for all, the degree of flexion corresponding to a given load, the crank of the fly-wheel should be fixed at the dead point, and steam at a known pressure should be introduced into the cylinder.

435. Torsion Pandynamometer. This instrument is designed to measure the power supplied to an engine or factory, by means of the torsion of the shafting through which the motive power is transmitted. *G. A. Hirn.*

At the extremities of one length of the shafting are keyed two toothed wheels of equal diameter, which gear, one directly and the other by an intermediate wheel, into two smaller pinions. The axes of these pinions govern by their extremities, which are directed towards each other, the four bevelled wheels of an ordinary differential movement. The two intermediate wheels of this movement are loose on a shaft, which is continued in a vertical direction, and made of a light steel rod. The result of this arrangement is, that if the shaft twists, this rod deviates, and forms with a vertical line an angle proportionate to the torsion to which the shaft is subjected. At the upper and loose extremity of the steel rod is secured, by means of a hinge, a horizontal and very light wooden bar, carrying at its extremity a roller, to which is attached a recording apparatus. This roller, when the shaft is at rest, lies in the centre of a wooden disc covered with paper, and revolving uniformly on a vertical axis.

So soon as the steel rod deviates from a vertical line, in consequence of the torsion of the motive shafting, the roller leaves the centre of the disc, and begins to revolve. The turns registered by the recording apparatus are exactly proportional to the torsion of the shafting.

The mean torsion of the shafting being thus known for a day's work, two parallel levers, placed in contrary directions, are securely fixed at the extremities beyond the two toothed wheels, and the loose extremities of the levers, so as to determine the deviation caused in the vertical bar by a given weight.

Simple proportion then gives the weight, corresponding to the mean angle obtained during a day's work, and it becomes easy to determine the mechanical work which corresponds to this angle.

435a. Method of ascertaining **Angles of Torsion** by means of instruments constructed by Professor Wischnegradski.

Laboratory of Mechanics, Technological Institute, St. Petersburg.

This is composed of a support fixed with two horizontal screws in the given section of the beam subjected to the process of torsion. This support upholds an horizontal axle, upon which is fixed an arc, bearing the teeth, whose pitch measures an angle of 2,440 seconds. This arc catches an endless screw, the head of which bears a circle divided into 244 equal parts, and furnished with a fixed decimal vernier; the arc also carries a very sensitive level, placed at the beginning of the experiment in a horizontal position.

The angle of torsion between the two given sections of the beam is calculated by two instruments exactly similar. The deformation of the twisted beam causes an inclination of the levels of both instruments; they are restored to their original position by means of the endless screws, and then is effected the reading of the angles described by the arcs of the two instruments. The difference between these angles is the angle of torsion wanted.

In the Laboratory of Mechanics of the Technological Institute of St. Petersburg the well-known apparatus of Mr. Wöhler is used for the torsion of trees, the photograph of which, taken together with the instruments for measuring the angles of torsion, is exhibited. For demonstrating how to use the instruments, a provisional apparatus is exhibited, wherewith the torsion of the beam is effected by means of a simple lever.

435b. Dynamometer Waggon, for marking and registering the tractive power, and the distances travelled.

Eastern Railway of France Company, Paris.

436. Theoretical Tension-Diagram for calculating the mechanical work in a steam cylinder.

H. Hädicke, Demmin, Pommerania.

X.—MEASUREMENT OF ANGLES.

437. A 10-inch Protractor, by Ramsden. *Royal Society.*

438. Clinometer of Precision, employed in 1865 by Professor Piazzi Smyth inside the Great Pyramid.

Prof. Piazzi Smyth.

This instrument was made to order by J. Cook and Sons, of York, in 1864, at the cost of Andrew Coventry, Esq., of Edinburgh, for measuring the interior slopes of the Great Pyramid. When thus used it was further mounted on a deep wooden beam, 120 inches long, armed with feet of gun metal.

The angle measuring portion of the instrument is a complete circle, provided with three pairs of opposite verniers, each reading to 10″ in order to eliminate errors of division as well as eccentricity, and the whole circle can be moved and clamped on its centre so as to repeat any required angle all round the circumference. On the voyage to Egypt a thermometer broke inside the box, and the mercury tarnished the divided rim in parts. The Pyramid angles were printed in Vol. II. of "Life and Work at the Great Pyramid," by Professor Piazzi Smyth, in 1867.

XI.—MEASUREMENT OF TIME.

, **Clock Dial.** The hours, six only, are indicated by ted Roman letters. The hand or pointer is formed of a ıg disc, painted in oil, with the subject of Aurora and ırs; it must have gone round four times in 24 hours. al is fitted in the original carved door of the clock. . 17th century. *Rev. J. C. Jackson.*

. **Clock,** in the shape of an orb of silver-gilt, covered lver filigree, suspended from a ring which is surmounted upid. The base of black marble is ornamented with enriched with silver-gilt filigree, enamels, and precious *German* (*Hamburg*). Dated 1685.
Rev. J. C. Jackson.

. **Clock,** in gilt ormolu case, engraved with figures of ı and festoons of flowers and fruit. It has a single hand, ikes the hours. The present pendulum has been sub- l for the old bob. *English.* Early 17th century.
Rev. J. C. Jackson.

. **Two Chronometers,** by Arnold. *Royal Society.*

a. **Chronometer,** with **Glass Balance Spring.**
E. Dent.

s the invention and handiwork of the late Frederick Dent, of the Strand al Exchange, and the only specimen in existence. The spring requires compensation for any given change of temperature than a steel spring nd the balance, which is composed of a glass disc, is compensated by small compensation laminæ mounted upon it.

. **Chronometer Balance,** "cut open" for action of heat ld; ordinary construction without auxiliary.
James Poole & Co.

). **Chronometer Balance,** in rough state from casting.
James Poole & Co.

. **Pocket Chronometer,** of silver, for inland observations.
James Poole & Co.

. **English Keyless Mechanism.** Models and specimens kmanship for fuzee and going barrel: ¾ plate lever and chronometer movements. *James Poole & Co.*

, **Keyless Watch,** complete, with fuzee.
James Poole & Co.

a. **Dipleidoscope with Telescope.** *M. Lutz, Paris.*

right to left in the Figures. The parts of the escapement are: (1), a pallet C; (2), a lever D, having the same axis as C, and resting normally against a fixed stop, from which it can lift, but below which it cannot fall; (it is in its normal position in Figs. 1, 3, and 4); (3), an arm E, of which one end can turn on a pin in D, and the other end, which is free, is lifted by the impulse pins, and rests on them successively; (it is resting on an impulse pin in Fig. 1); (4), a first detent F, against which C sets when at the top of its lift; (C is thus set against F in Fig. 1); (5), a second detent G; and (6), set on a spring, a stop H, against which the scape wheel locks.

The action of the escapement is as follows:—Suppose (as represented in Fig. 1) the scape wheel to be locked and that C has been lifted from its lowest position through an angle $\alpha + \beta$ to the top of its lift. Suppose also that the pendulum is moving to the right from the end of its swing at the left. First, a slot or a pin in the pendulum rod (a pin is supposed here for simplicity sake, and the path of the pin is shown by the dotted curve in each Fig.) lifts G, idly, which falls back to its normal position, that of Fig. 1, immediately the pin has passed; then the rod itself, towards the end of its swing to the right, impinges against a "beat" pin c in C, and, still rising, carries C with it as far as it goes through a further angle γ. In rising through γ, C takes up D with it, and the free end of E, which was resting on the impulse pin by which it was lifted, is carried clear of that pin (now see Fig. 2), and drops on to B^1, the impulse pin next below, depressing F in its drop, and afterwards holding F down (see E and F in same Fig.). The pendulum now returns, from right to left, and C with D falls back through γ, D being arrested at the fixed stop; the free end of its arm E still resting on B^1, and still holding F down. The pendulum continuing its descent, C falls

Fig. 1.—The pallet against the first detent.

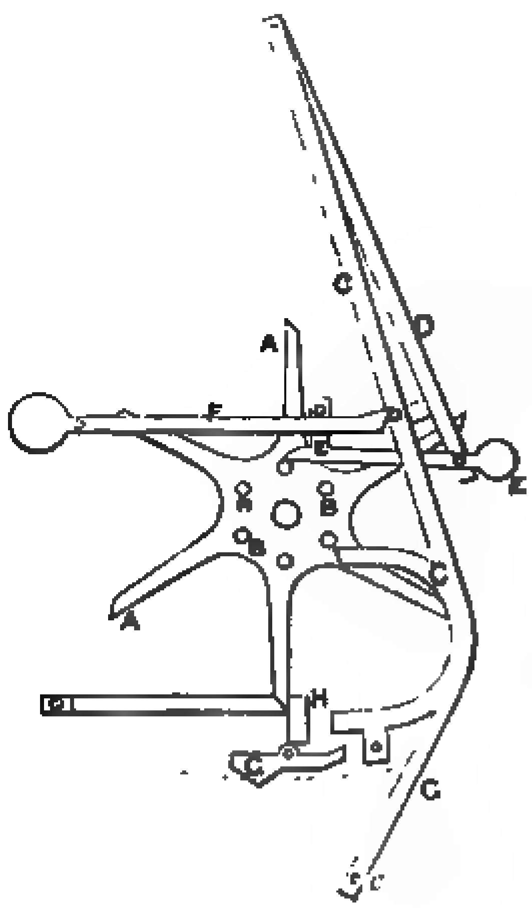


Fig. 2.—At the end of the pendulum swing to the right.

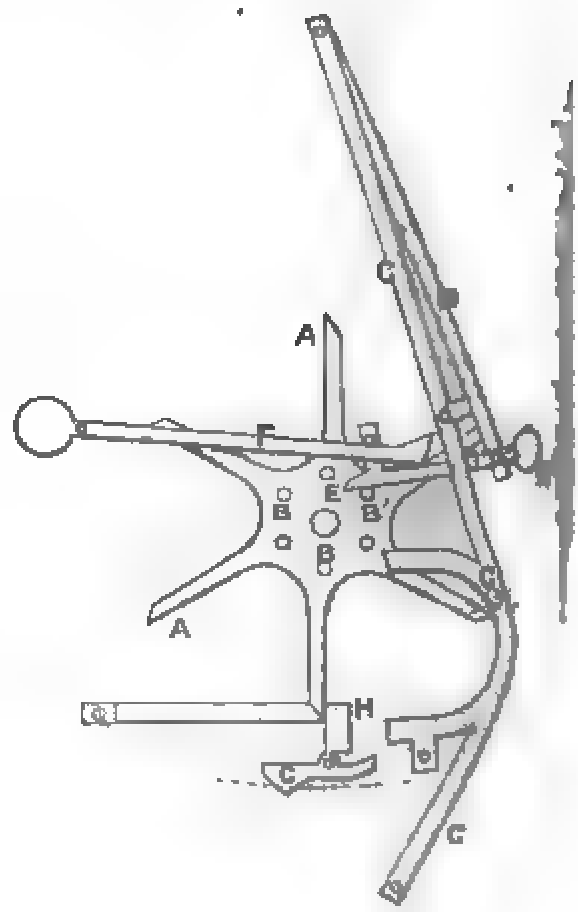


Fig. 3.—The pallet against the second detent.

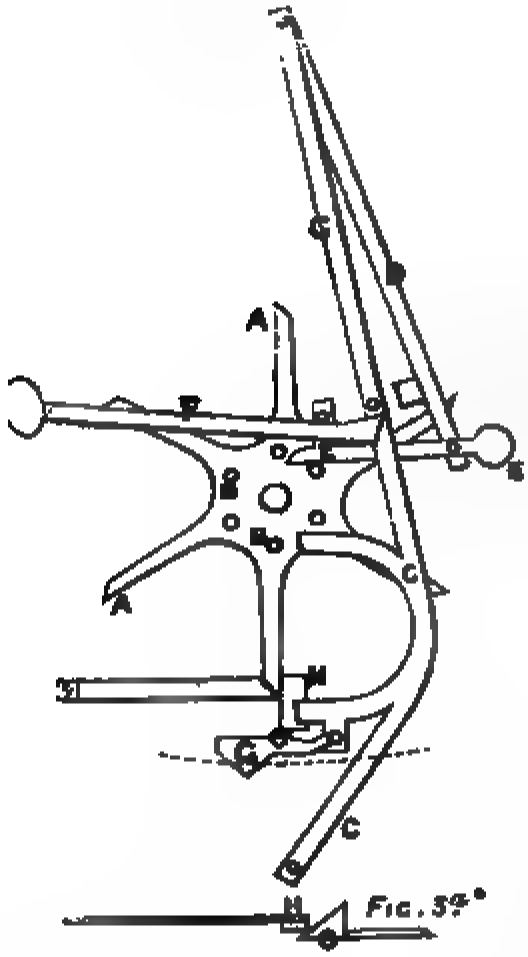
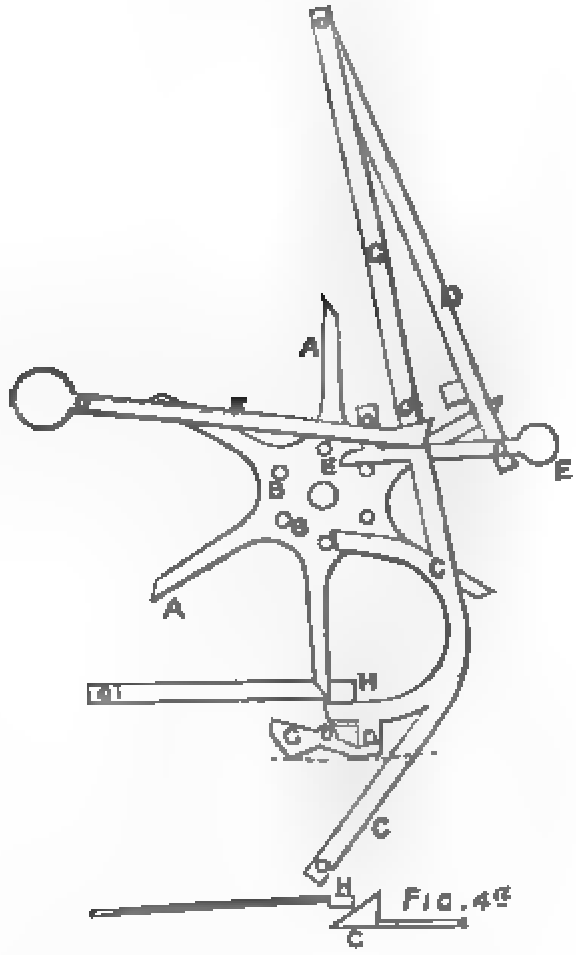


Fig. 4.—The pallet at its lowest position.



back through β, the detent F being out of the way, as far as the detent G (here see Fig. 3), where it stops. In this fall through β, C gives the impulse. The pendulum now moves on by itself, until presently the pin in its rod once more lifts G, not however idly now, but releasing C, which falling back further through a + to its lowest position (shown in Fig. 4), unlocks the scape wheel from H. The position of H with respect to that part of C which acts upon it is shown in plan in Figs 3a and 4a, in Fig. 3a just before, and in Fig. 4a just after the unlocking of the scape wheel. The pendulum having lifted G, continues its swing to the extreme left, whence it was supposed started. The scape wheel, free to move, lifts C and also E, the detent F, which is weighted so as to rise of itself, following E's motion, and being in position to hold C when the lifting is done, which is the case just before the next long tooth of the scape wheel coming round and setting against H (which returned to its normal position as C in lifting cleared it), things are again as represented in Fig. 1.

It will be seen from the above description that the pendulum is never in connexion with the clock train, not even for unlocking, and is therefore exposed to no inequality whatever in the work it has to do. The pressure of the scape wheel against the stop by which it is locked varies. This variation, however, is altogether apart from the pendulum, as the unlocking is done by the pallet.

In the arrangement drawn the impulse is not given across the line of centres; it can, however, be so given by appropriate modifications of the various parts.

466a. Jamin's Compensator. *M. Lutz, Paris.*

466b. Diagram representing the Great Westminster Clock. *E. Dent and Co.*

This is by far the largest and most powerful clock in the world. The clock frame is 15 feet 6 in. long, and 4 feet 10 in. wide. The escapement is the double three-legged gravity, and the pendulum which controls it weighs 685 lbs., is 14 feet 5 in. long, and vibrates once in two seconds. Its compensation is effected by zinc and iron tubes. The dials, four in number, are 22½ feet in diameter, and the bell on which it strikes, "Big Ben," weighs nearly 14 tons.

466c. Diagrams representing the New Standard Clock of the Royal Observatory, Greenwich. *E. Dent and Co.*

This clock has an escapement, shown in the front of the picture, invented by the Astronomer Royal, which in some degree resembles the chronometer escapement, but in nearly every other particular the clock exhibited by us is an exact counterpart of it. The clock has a "barometric compensation" which is shown in the second diagram.

466d. A Collection of Compensation Balances. *E. Dent.*

No. 1. An early form of balance.—Steel connexions are fastened near the root of the rims of a plain brass balance; the expansion or contraction of these being less than that of the central brass arm, the rims are by any change of temperature tilted towards or away from the axis of motion.

No. 2. An early form of balance.—Loops formed of brass melted on to steel are fastened upon each side of the axis of motion, in consequence of the greater expansion or contraction of the brass, these open or close with the change of temperature, and drag in or thrust out the small brass weights, to which they are attached by wires.

No. 3. An early form of balance.—The rims are of brass melted upon steel, the brass being outwards; with any change of temperature the rims open or close.

No. 4. An early form of balance.—A flat steel bar has soldered to its extremities underneath pieces of brass; the ends of the steel bar carry uprights bearing weights upon their summits, the brass pieces underneath having a different rate of expansion to the steel, bend it either upwards or downwards, and tilt the uprights carrying the weights towards or away from the axis of motion.

No. 5. A balance of similar design, but having brass melted upon the steel, instead of merely being soldered to its extremities.

No. 6. A balance of modern design, similar in its action to No. 5.

In order to obtain perfect compensation, it is found that for an increase of temperature the compensation weights must advance more rapidly towards the axis of motion, than for the same decrease of temperature they would recede from it. This peculiarity necessitates what is called secondary compensation. The following balances have been introduced to obviate this error:—

No. 7. Compensation pieces formed of brass melted upon steel receive such curves, that with any increase of temperature the compensation weights move towards the axis of motion more directly than they recede from it with any decrease of temperature. (Dent's balance.)

[redacted]

compensation bar is formed, as in No. 5, by brass being melted and this bending upwards or downwards, with any change of ·, tilts the weights carried by the staples towards or away from motion. But the staples are themselves compensation pieces, and : weights higher with any increase, and depress them with any ' temperature, and in this manner increase the rate at which ch the axis of motion, and diminish the rate at which they recede Dent's patent balance.)

balance of nearly the same form as No. 6, but the section of its what in the shape of a prism ; the form of the rim offers less re- the motion of the compensation weight inward than outward. istered balance.)

A balance similar to No. 5 is mounted upon the arm of a balance No. 6. With any increase of temperature, the first balance can econd, but with any decrease of temperature its motion is checked. combination, therefore, is more effective in the heat than in the wer's form.)

An experimental balance, contrived for the purpose of removing n the centre, both with an increase and decrease of temperature. s form.)

An auxiliary compensation is added to a balance similar in form The auxiliary consists of two double compensation pieces, and the carry weight towards the axis of motion, both for an increase and ' temperature. The effect of the main compensation weights is creased in the heat and diminished in the cold. (Dent's balance.)

A balance of similar design to No. 8, but arranged so that the compensation can be altered with greater facility. (Dent's

A balance having the same general operation as No. 8, but the btained by straight bars only. The secondary compensation can red without inconveniently disturbing the main compensation, and ut producing any great alteration in the time of the chronometer. ance.)

Drawings of Compensation Balances, Escape- nd other appliances connected with the construction of d Watches. *The British Horological Institute.*

Escape Wheel.
Escapement.
: Roller Lever Escapement.
'in Lever Escapement.
meter Escapement.
: Escapement.
ooth Lever Escapement.
Escapement.
ntal Escapement.
Roller Lever Escapement with Compensation Balance.
Chronometer Escapement.
sation Adjustment by Sir G. B. Airy, Astronomer Royal,

Three-legged Gravity Escapement as used in the West- reat Clock.
eat Clock Escapement.

Pin Wheel Clock Escapement.

Zinc and Steel Compensation Pendulum as used in the Westminster Great Clock.

467a. Compensation Balance arranged in Two Groups.

GROUP I.—Earnshaw's balance with circular rim (1780), and modifications thereof to the present time.

Earnshaw's balance.
Modification of do.
  Do. do.
  Do. do., with extra adjusting screws.
  Do. do., with screws for weights.
  Do. do. do. do.
  Do. do., with screws for more minute adjustment.
  Do. do. do. do. do.
  Do. do., with double weights.
  Do. do., with variation of weights.
  Do. do., with auxiliary by Molyneux.
  Do. do., do. do.

GROUP II.—Balances of a form distinct from Earnshaw's, from Hardy (1805) to the present time.

Hardy's balance.
Arnold's do.
Dent's do.
Balance with laminated arm and rim.
Hartney's balance.
  Do. do. cup.
Modification of Hartney's balance.
Kullberg's flat rim balance.
  Do. double-flat rim balance.
Cole's balance.

The British Horological Institute.

467b. Modification of Molyneux's Auxiliary.

Eiffe's mercurial auxiliary.
Poole's auxiliary.
Example of recent auxiliary.
  Do. do. do.
  Do. do. do.
Compensation adjustments by the Astronomer Royal (Sir G. B. Airy).

The British Horological Institute.

468. Enlarged Model of Compensation Watch Balance.

The British Horological Institute.

469. Ordinary Marine Chronometer Compensation Balance. *The British Horological Institute.*

470. Models (twelve) **of Compensation Balances,** showing various attempts to overcome what is known as the "Error" of the ordinary Compensation Balance.
The British Horological Institute.

471. Models (ten) **of Compensation Balances,** showing various attempts to overcome what is known as the "Error" of the ordinary Compensation Balance, by the late Thomas Hewitt.
The British Horological Institute.

472. Marine Chronometer by Earnshaw.
The British Horological Institute.

473. Marine Chronometer with Midge's Escapement.
The British Horological Institute.

474. Grossmann's Micrometer.
The British Horological Institute.

475. Model of "Ferguson's Paradox."
The British Horological Institute.

476. Model of Cole's Resilient Escapement.
The British Horological Institute.

477. Calliperi̇ng Engine, by the late Richard Roberts.
The British Horological Institute.

478. Models of English and French Repeating Motions for Watches. *The British Horological Institute.*

479. Watch Movement.
The British Horological Institute.

480. Marine Chronometer Movement.
The British Horological Institute.

481. Collection of Watch and Chronometer Balance Springs. *The British Horological Institute.*

482. Map showing allowance of time to be made for velocity of sound as applied to the **Westminster Clock Bell.**
The British Horological Institute.

483. Universal Dial, made in 1616 for Prince Charles.
The Royal United Service Institution.

Presented to the United Service Museum, in 1832, by Captain W. H. Smyth, R.N., K.F.M., F.R.S., &c., &c.

484. Timekeeper, which was twice carried out by **Captain Cook.** *The Royal United Service Institution.*

structed repose pendulum, executed with sufficient stability. Not only is the expansion coefficient of the separate bars exactly determined in the pyrometer, but likewise the whole pendulum is directly controlled, as regards length and extension, in the pyrometer. The pyrometer employed is of quite a novel construction; the observation takes place in a liquid, *without contact*, under two micrometer microscopes. Accuracy: 1 scale division = $\frac{1}{1000}$ millimeters. As the observation through the microscope requires perfectly clear water, the uniformity of its temperature is ensured; the bars likewise must be quite homogeneous, as otherwise a bending of them will take place by a change of the temperature, whereby the terminal ends will move out of the range of vision. With regard to compound pendulums, the centre of gravity is to be found by means of a balance the point of flexion of the spring of which is known to the exhibitor; in a quite homogeneous and uniformly strong balance it is exactly in the centre. By means of a bar the centre of gravity is indicated on the length of the pendulum,* and the whole pendulum is controlled in the pyrometer as to temperature and stability.

521. Model Escapement. *F. Dencker, Hamburg.*

An anchor escapement, enlarged tenfold, with an impulse derived from the chronometer and acting like the same from fork upon balance. The same moves likewise without oil. The straight lines of the fork and the release stone render a quite exact execution possible, and consequently an effect which almost equals the direct impulse from wheel upon balance, without detracting from the great insensibility of the anchor escapement. Arranged for quarter seconds, it will be very useful for determining the time on journeys and on sea. The last seconds are regulated by a curb, permitting only little motion, but being securely guided by means of a screw. The last regulation by the screws always disturbs the equilibrium of the balance, and effects thereby a doubling of the errors at the change of the position. The flat spiral spring has an inner and an external curve.

522. Gold Watch. *F. Dencker, Hamburg.*

The pocket watch has been exactly executed according to this model in the exhibitor's establishment at Geneva. It is provided with a flat spiral spring hardened in fire according to his invention. Up to the present time no flat spiral springs are ever hardened in fire.

523. Watch with spindle without spiral spring; constructed in the East in the first half of last century, indicating month, day, and hour in Arabic figures. (Remarkable for its age and origin.) Property of H.H. Prince Pless, Fürstenstein.

Committee of Breslau.

523a. Watch, thickness of a crown piece, made for the late Sir C. Wheatstone by Mr. A. Stroh.

---

* The extension of the parts to be employed being known, a pendulum can be determined by calculations which swings in exactly one second.

[SEC]TION 4.—KINEMATICS, STATICS, AND DYNAMICS.

WEST GALLERY, GROUND FLOOR, ROOM K.

I. SPECIAL COLLECTIONS.

[COLLECT]ION OF APPARATUS USED BY 'SGRAVESANDE TO ILLUSTRATE HIS PHYSICAL RESEARCHES.

'sGravesande's Apparatus to demonstrate the [...]f **Centrifugal Force.**
Professor Dr. P. L. Rijke, Leyden.

[G]ravesande's "Physices Elementa Mathematica," 3rd edition, Vol. [...])

'sGravesande's Apparatus to demonstrate the [...] of the **Wedge.** *Professor Dr. P. L. Rijke, Leyden.*

'sGravesande's Apparatus, to show, by means of a [...]n furnished with weights and springs, that the same [...] of **Mechanical Labour** produces the same quantity [...]g **Force.** *Professor Dr. P. L. Rijke, Leyden.*

'sGravesande's Apparatus to demonstrate the **Laws** [...]ng **Bodies.** *Professor Dr. P. L. Rijke, Leyden.*

'sGravesande's Apparatus for **Parabolic Motion.**
Professor Dr. P. L. Rijke, Leyden.

[COLLEC]TION OF KINEMATIC MODELS, EXHIBITED BY THE KÖNIGL. [GEWE]RBE-AKADEMIE, BERLIN, PROF. REULEAUX, DIRECTOR.

[The m]odels in this collection are connected throughout with Professor [...]'s treatment of the theory of machines. Their nature will be found [disc]ussed in his "*Theoretische Kinematik*" (Vieweg und Sohn). The [English e]dition of this work (Macmillan), translated and edited by Professor [...]r B. W. Kennedy, C.E., of University College, London, will, it is [...] ready early in May. The English names of the mechanisms here [are] those used by Professor Kennedy in his translation.

554. III.—Simple Kinematic Chains and Mechanisms.

20. Quadric cylindric-crank chain.
21. Slider-crank chain.
22. Quadric conic-crank chain.
23. Reduced slider-crank chain.
    The link *c* omitted.
24. Reduced slider-crank chain.
    Links *a* and *e* omitted.
25. Reduced conic-crank chain.
    The link *c* omitted.
26. Quadric crank chain with slot and sector.
27. Single crossed slide chain.
28. Double crossed slide chain.
29. Simple spur-wheel chain.
30. Simple spur-wheel chain with annular wheel.
31. Endless screw.
32. Stand for carrying the above models when in use.

555. IV.—Crank Trains.

33. Double slider-crank.
34. Slider-crank.
    With centroids.
35. Slider-crank.
    With centroids.
36. Double slider-crank.
    With centroids. (The centroids are here Cardan's circles.)
37. Slider-crank.
38. Skew double slider-crank.
39. Double slider-crank with curved slide.
40. Double slider-crank with skew slide.
41. Lever-crank.
42. Double slider-crank with curved slide.
    With pin expansion.
43. Slider-crank.
    Link *b* is here a disc.
44. Slider-crank.
    With adjustable connecting rod.
45. Slider-crank.
    With adjustable cross-head.
46. Slider-crank.
    In the form of a marine engine.
47. Slider-crank.
    Slotted link gear.
48. Slider-crank.
    Double slide gear.

(Norman Wheeler).

50. Slider-crank, with pin expansion, 2 within 1.
51. Slider-c[illegible], with pin expansion, 1 within 2.
52. Slider-c[illegible], with pin expansion, 3 within 2.
53. Slider-[illegible], with pin expansion, 2 within 3.
54. Slide[illegible]k, with pin expansion, 2 within 3.
[illegible] expansion.
55. Slid[illegible] pin expansion, 1 within 2 within
56. Slide[illegible] with pin e[illegible]ion, 3 within 2 within
57. Slider-crank, with pin e[illegible]sion.
Adjustable stroke.
58. Swinging block (sl[illegible]).
59. Turning block (slid[illegible]
60. Skew ([illegible]
61. Turnin[illegible]
With pin expansion (can be used also as a turning slider
62. Turning block (slider-crank).
With reduced centroids.
63. Double crank (drag-link coupling).
With reduced centroids.
64. Turning block (slider-crank), Redtenbacher's "[illegible]
Kurbelschleife."
Quick return motion; the stroke is adjustable.
65. Swinging slider-crank.
65*a*. Swinging double slider.
66. Swinging skew double slider.
67. Conic crank-train.
68. Isosceles double-crank (Galloway).
Mean velocity, ratio 1 : 2.
69. Isosceles double-crank (Galloway).
Mean velocity, ratio 1 : 2; arrangement for crossin
by Reuleaux.
70. Anti-parallel cranks (Reuleaux).
Special arrangement for crossing dead points.
71. Anti-parallel cranks (Reuleaux).
With centroids, which are ellipses.
72. Anti-parallel cranks (Reuleaux).
With centroids, which are ellipses and hyperbolæ
73. Double parallel crank train, used as a couplin
For transmitting uniform rotation.
74. Double parallel crank train, used as a couplin
For transmitting uniform rotation.
75. Crank train for transmitting uniform rotatio
76. Crank train for transmitting uniform rotati

Differential crank train (Römer).
Numbers of teeth, 56 and 56, with apparatus for tracing diagrams.

Differential crank train (Römer).
Numbers of teeth, 56 and 57, with apparatus for tracing diagrams.

Differential crank train (Römer).
Numbers of teeth, 30 and 90, with apparatus for tracing diagrams.

Hooke's joint.
Universal joint (Blees).
Universal joint (Polhem).
Universal joint (Reuleaux).
Universal joint (Klein).
Universal joint (Klein).
Simplified by Reuleaux.

Double Hooke's joint.
The velocity ratio here can be made constant.

6. IVa.—Mechanisms for describing Straight Lines ctly or approximately).

Roberts triangle, "parallel motion."
Triangle motion, inverted, by Reuleaux.
Elliptic linkwork (Nehrlich), 3rd form, inverted.
Elliptic linkwork (Nehrlich), 3rd form, inverted.
Hypocycloidal linkwork.
Hypocycloidal linkwork, inverted, by Reuleaux.
Epicycloidal linkwork, Reuleaux.
Elliptic linkwork, inverted.
With the whole motion.

Tchebischeff's linkwork.
Arranged so that it can be inverted.

Conchoidal linkwork, 1st form.
Conchoidal linkwork, 3rd form (Reichenbach).
Conchoidal linkwork, 3rd form (Reuleaux).
Lemniscoidal linkwork, 1st form (Watt).
Lemniscoidal linkwork, 2nd and 3rd forms.
Lemniscoidal linkwork, 1st form, inverted (Reuleaux).
Lemniscoidal linkwork, 2nd and 3rd forms.
Steam engine model with Watt's planet wheels.

Sector mechanism (Reuleaux).
Involute.

Sector mechanism (Reuleaux).
Cycloid.

Sector mechanism (Reuleaux).
Cycloid.

Cartwright's mechanism.
Maudsley's mechanism.
Tchebischeff's mechanism.

109. Harvey's mechanism.
110. Harvey's mechanism.
111. Pantograph.
  With elliptic linkwork, 1st form.
112. Pantograph.
  With prism guide.
113. Semi-pantograph.
  With prism guide.
114. Semi-pantograph.
  Steam engine model.
115. Rhombic linkwork.

557. V.—Apparatus for describing Curves.

116. Ellipsograph.
117. Ellipsograph, by Slaby, on Haman and Hempel's system
  Describes also cycloids. Dr. Slaby's construction contains essential improvements.
118. Elliptic chuck (Leonardo da Vinci).
119. Elliptic chuck (Delnest).
120. Sinoid and cardioid tracing gear.
121. Curve tracing apparatus.
122. Curve tracing apparatus.
123. Mechanism for describing Lissajous' figures.
  Describes also ellipses.
124. Hastie's conoid gear.
125. Tricentric gear.
  For the construction of three-grooved taps, &c.
126. (Form-) copying machine.
127. Rose-engine.
128. Rose-engine.
129. Rose-engine.
130. Rose-engine, special form.

558. VI.—Parallel or Translating Trains.

131. Parallel ruler.
  Single and double.
132. Parallel ruler.
  With crossed bars.
133. Complete lever parallel train.
  Weighing machine, of Roberval.
134. Incomplete lever parallel train.
  Weighing machine, of Milward.
135. Incomplete lever parallel train.
  Weighing machine, of Farcot.
136. Incomplete lever parallel train.
  Weighing machine, of Schwilgué.

559. VII.—Compound Parallel Trains.

137. Feathering paddle-wheel, of Buchanan.
A combination of trains similar to parallel rulers. The floats remain always vertical.

138. Feathering paddle-wheel, of Oldham.
The floats rotate about their axes as the wheel revolves.

139. Feathering paddle-wheel, of Morgan.
With eccentric ring.

560. VIII.—Higher Couplings.

140. Uhlhorn's coupling.
141. Oldham's coupling.
142. Reuleaux's grooved disc coupling.
143. Köchlin's cylindric coupling.
144. Schürmann's cylindric coupling.
145. Conic coupling.
146. Pouyer-Quertier's coupling.

561. IX.—Toothed-wheel Trains.

147. Spur wheels (point-paths used for profiles).
148. Returning spur-wheel train.
149. Returning spur-wheel train, with annular wheel.
150. Returning spur-wheel train, with annular wheel.
151. Returning spur-wheel train, with two annular wheels.
152. Returning spur-wheel train, with two annular wheels.
153. Returning spur-wheel train, with intermediate wheel.
154. Returning spur-wheel train, with intermediate wheel.
Reuleaux's so-called halving spur-wheel train.

155. Returning spur-wheel train.
With Marlborough wheel.

156. Spur-wheel train.
The centroids are Cardan's circles.

157. Beylich's universal wheels.
"Pin-wheels."

158. Cylindric friction wheels.
Held by axial pressure.

159. Screw wheels.
Working as spur-wheels.

160. Screw wheels.
Screw wheel and rack.

161. Bevel wheels.
Plane- (face-) wheel and full wheel.

162. Mangle-wheel train.
Automatic reversal.

[redacted]

163. Mangle-wheel train.
164. Mangle-wheel train.
With internal teeth.

165. Whitworth's feeding gear for drills.
The drill is under a constant pressure.

166. Reversing gear, claw coupling.
With bevel wheels.

167. Reversing gear, bevel wheels.
168. Reversing gear, returning wheel gear.
By Reuleaux.

169. Reversing gear, Sellers' arrangement.
Open and crossed belts.

170. Reversing gear, with three pulleys.
171. Face-wheel and runner (Rupp).
172. Speed changing gear (Sellers).
For lathes.

173. Speed changing gear with double pulleys.
174. Reversing and disengaging train (radial).
Wheels of 103 and 53 teeth respectively.

175. Reversing and disengaging train (Fairbairn's).
176. Reversing and disengaging train (Brown's).
177. Engaging and disengaging train (Platt's).
178. Engaging and disengaging train (Curtis').

Globoid Gearing.

179. Globoid screw wheels ; spheric screw and wheel.
Reuleaux.

180. Globoid ring, screw, and wheel.
Reuleaux.

181. Skew globoid ring, conic screw and tooth.
Reuleaux.

182. Globoid ring, cone, and wheel.
Used by Stephenson in locomotive reversing gear.

183. Crossed globoid ring, screw, and tooth.
Reuleaux.

184. Crossed globoid ring, screw, and tooth.
Reuleaux.

185. Globoid screw and screw wheel.
Endless screw.

186. Globoid screw.
Applied in horse gins; velocity ratio 1:12.

Parallel Wheels.

187. Parallel wheels with 24 teeth.
Reuleaux. The teeth are revolutes.

188. **Parallel wheels with 6 teeth.**
Reuleaux. Would work also with 3 teeth. The teeth are pins.

189. **Parallel wheels with 5 teeth.**
Reuleaux. One wheel annular.

190. **Parallel wheels with 24 (pin) teeth.**
Reuleaux. The parallelism is destroyed by displacing the axes.

Planet Wheel Chains.

191. **Planet wheel chain.**

192. **Planet wheel chain, $a=b=\infty$.**
With excanching wheels.

193. **Planet wheel chain, $a=b=\infty$.**

194. **Planet wheel chain, with annular wheel.**

195. **Planet wheel chain, $b=c=\infty$.**

196. **Hyperboloidal endless screw.**

562. X.—Belt-trains.

197. **Returning belt-train.**
Shows the alteration of velocity due to the slipping of the belt.

198. **Skew belt-train.**
Acts in one direction only.

199. **Belt-train with crossed guide pullies.**
The necessary tension is given to the belt at the instant it is thrown into gear.

563. XI.—Slider-cam Trains.

200. **Sinoidic cams. Cardioids.**
Open cam with roller, pair-closure.

201. **Sinoidic cams. Cardioids.**
With second disc and centroid.

202. **Sinoidic cams. Cardioids.**
Pair-closure.

203. **Sinoidic cams. Polar sinoid.**
With centroid.

204. **Sinoidic cams. Polar sinoid.**
With centroid.

205. **Cams with discontinuous profiles. Curve-triangle in skew curved slot.**
With centroid.

206. **Cams with discontinuous profiles. Equilateral curve-quadrangle.**
With centroid.

207. **Cams with discontinuous profiles. Equilateral curve-pentagon in straight slot.**

208. Cams with discontinuous profiles. Equilateral curv-
gon in adjustable slot.
Both parts are adjustable.

209. Cams with discontinuous profiles. Curved disc in c
slot.
Both parts are adjustable.

210. Cams with discontinuous profiles. Curved disc.
For the motion of a slide valve.

211. Cams with discontinuous profiles. Disc with looped
With shuttle, used in printing presses.

212. Slider-cam, two-lobed cylindric sinoid.
Force-closure.

213. Slider-cam.
Force-closure.

214. Slider-cam, cylindric sinoid.
215. Screw reversing train of Whitworth.
216. Steering gear of Scott and Sinclair.
217. Steering gear of Steel (Greenock).
218. Steering gear of McWilliam.
219. Steering gear of Reed.
220. Steering gear of Rogers.
221. Steering gear of Reuleaux.
222. Boring machine.
223. Boring machine (Stehelin).
224. Boring machine (Reuleaux).
225. Differential screws.
226. Differential screws, with wheel train.
227. Double screw train (Napier).
Self-acting return.

228. Cam reversing train (Girard).
For governors.

229. Leading screw with disengaging gear.
With self-acting disengagement.

230. Screw disengagement (Whitworth).
With pallet action.

231. Screw heckling machine (Houldsworth).

564. XII.—Ratchet Trains.

232. Click train.
With two external and one internal clicks.
233. Centrifugal click train.
If rapid rotation occur, the centrifugal force throw
234. Silent click train.
235. Pinching click train.
236. Click train of Wilbers.

237. **Ratchet train of Langen.**
Used in gas engines.

38. Turning ratchet gear (Maltese cross wheel).
39. Turning ratchet gear (incomplete cross wheel).
40. Turning ratchet gear (spur wheel).
41. Ratchet train.
With automatic disengagement.

42. Ratchet train, with pin teeth.
With automatic disengagement.

43. Ratchet train (Reed).
With automatic disengagement and fall.

44. Ratchet train, with fast click.
45. Single acting ratchet train.
The direction of motion can be altered.

46. Double acting ratchet train.
47. Reversing ratchet train (Francis).
Used for governors.

48. Dividing machine (Nasmyth).
49. Lagarousse ratchet gear.
With eccentric.

50. Crown wheel ratchet train.
51. Tooth ratchet train, with double acting free click.
Model illustrating action of a force pump.

52. Escapement train (Mudge).
Can be held in the stand, No. 32.

3. Throttle click train.
Illustrates the action of the throttle valve.

4. Ratchet train, with pinching clicks.
5. Ratchet train, with several clicks.
6. Ratchet train, with free clicks.
Directing gear can be added so as to illustrate the action of a steam engine.

7. Ratchet train, with fast clicks.
Ratchet train, with Farey's director.
Ratchet train, with Watt's director.
Watt's automatic valve gear.

Double acting ratchet gear.
Ratchet train, with cataract director (Hoffmann).
Double acting ratchet gear.
(Reuleaux.) Shows that the steam engine is a ratchet train. The model can be worked with various forms of directing gear; it stands upon a large mahogany frame with columns.

Apparatus for using with Nos. 244 to 254 :—Column with fly wheel and two connecting rods.

H 2

Escapements.

264. Graham's anchor escapement.
265. Escapement of Reuleaux.
266. Pin escapement of Lepaute.
267. Escapement of Denison.
    With three-toothed escape wheel.
268. Gravity escapement of Denison (1860).
    As in the clock at the Houses of Parliament.
269. Gravity escapement of Denison.
270. Spindle escapement.
271. Cylinder escapement.
272. Anchor escapement.
273. Chronometer escapement of Jürgensen.

564a. XIII.—Chamber-crank Gears and Chambe- wheel Trains.

274. Chamber-crank gear, Simpson and Shipton.
    Steam engine.
275. Chamber-crank gear, Bährens, Napier, Bompard.
    Steam engine.
276. Chamber-crank gear, Wedding, Cochrane.
    Ventilator.
277. Chamber-crank gear, Ramelli.
    Pump.
278. Chamber-crank gear, Beale.
    Gas exhauster.
279. Chamber-crank gear, Cochrane.
    Steam engine.
280. Chamber-crank gear, Pattinson.
    Pump.
281. Chamber-crank gear, Minari, Stocker.
    Steam engine and pump.
282. Chamber-crank gear, Ramey.
    Steam engine and pump, with elliptic wheels.
283. Chamber-crank gear, Lemielle.
    Ventilator.
284. Chamber-crank gear, Cochrane.
    Steam engine.
285. Conic crank gear, Davies.
    Steam engine.
286. Parallel crank gear, Galloway.
    Steam engine.
287. Chamber-wheel train, Pappenheim.
    Pump.
288. Chamber-wheel train, Fabry.
    Ventilator for mines.

. Chamber-wheel train, Fabry.
. Chamber-wheel train, Root.
Blower.

Chamber-wheel train, Root.
Blower.

Chamber-wheel train, Payton.
Water-meter.

Chamber-wheel train, Evrard.
Pump.

Chamber-wheel train, Repsold, Lecocq.
Pump.

Chamber-wheel train, Dart, Behrens.
Pump.

Chamber-wheel train, Ganahl, Eve.
Chamber-wheel train, with three wheels.
Screw-wheel chamber train, Révillion.
Ventilator.

II. ELEMENTARY ILLUSTRATIONS.

3a. Parallelogram of Forces.
Dr. G. Krebs, Frankfort-on-the-Maine.

3b. Inclined Plane.
Dr. G. Krebs, Frankfort-on-the-Maine.

3c. Inclined Plane, constructed by Professor Dr. Bertram, :illor of the Board of Education. *Ferdinand Ernecke, Berlin.*

inclined plane is represented by two parallel iron rods, which can be at any angle desirable to the horizontal bar.

:e tracts (distances) can be measured on the same :—

he length of the inclined plane, that is to say, the distance from the z point (centre of motion) to the perpendicular iron support bar, which ins the plane in its proper position.

The base, that is to say, the horizontal distance from the centre of motion support bar; the same is read on the horizontal pedestal.

The height, that is to say, the plumb line from the terminal point of the listance to a horizontal line laid through the centre of motion; this l on the support bar, the zero point of which is situated on a level with ntre of motion.

: burden on the inclined plane can be arrested in two different ways: by a motion parallel to the inclined plane, or by a horizontal motion. arriage of the roller can be turned, and the pulling string can, therefore, ced parallel to the inclined planes or horizontally. The double division : slitted support bar serves for observing the horizontal position of the

every experiment the burden carriage, that is, the two-wheeled axle ts scale, is balanced with the scale which is suspended on the string. s effected by tare weights. Then the burden and the power of traction asted by means of the measured distances, that is to say, the weights are balancing each other in the burden scale and the traction scale.

f the string of the inclined plane runs parallel, then the burden is

oportioned to the traction as the length of the inclined plane is to the ight.

For example, if the length be 80 and the height 40, then 20 grammes in the ırden scale will be balanced by 10 grammes in the traction scale.

2. If the string runs horizontal, then the burden is proportioned to the action as the base of the inclined plane to the height.

For example, if the basis be 40 and the height 40, then 4 grammes in the ırden scale will be balanced by 20 grammes in the traction scale.

In order to make the difference in the two cases intelligible, such positions the inclined plane are advantageous in which the three distances are indi- ted by round figures, such as height, 20; length, 29; base, 21. The weight in the traction scale balances then with the string in horizontal position e weight 21; and with the string parallel the weight 29 will be equipoised. ith the height 30 and the base 40 the length will be 50, and 30 grammes in e traction scale will balance 50 grammes in the burden scale with parallel otion, whilst the burden at a horizontal motion will amount to only 40 ammes.

528d. Parallelogram of Forces, constructed by Professor r. Bertram. *Ferdinand Ernecke, Berlin.*

Apparatus for demonstrating the theorem of the parallelogram of forces. If two adjacent sides of a parallelogram represent in magnitude and direc- n two forces acting at a point, the diagonal through the point will represent ir resultant in magnitude and direction.

This theorem is illustrated by the apparatus. The angular point of the ıallelogram is the (white) peg, over which a ring has been placed, on ich are fastened the three cords; the magnitude of the forces is deter- ned by the weight in the scales, the direction passes along the three rails, which the one, AB, which is stationary, vertically upright; the second , and likewise the third, AE, movable around the peg A, always moves in elongated diagonal of the parallelogram BADF. The greatest of the ces is always taken in the direction of AB, and determined as equal to , and those of the two others is read on the graduations of the lines BG AF.

f, for example, the parallelogram is placed so that the lines AB are equal 100, BF = 70, AF = 80, the ring in that case will poise freely without ıing into contact with the peg, if the weights in the scales amount respec- ly to 100, 70, 80 grammes; of course must the equilibrium of the scale ghts be adjusted previously by tare weight.

528e. Centrifugal Apparatus, complete.

Ferdinand Ernecke, Berlin.

529. Drawing. Experimental demonstration of the theory he parallelogram of forces or velocities, used by the exhibitor e 1835. *Professor Daniel Colladon, Geneva.*

wo small pulleys are placed at some distance from each other on the edge table. On the opposite edge, held by the hand, is a small ball of the of a musket ball, to which are attached, by one of their extremities, two oidal springs of fine brass wire; the other extremity of these two springs awn parallel to the plane of the table by cords passing over the pulleys, themselves stretched by the weights P and P′. The table being sprinkled lycopodium, two lines are traced upon it, marking in direction and in- ity the tensions of the two springs which draw the ball, which are equal o weights P and P′. On discharging the ball it traces on the table ght line, which is in the direction of the diagonal of the parallelogram orces P and P′ of the two springs.

III. PRINCIPLES OF MECHANISM.

a. **Models** (13) of the various **Linkworks** for effecting ict rectilinear motion of a point, commonly known as el motions." *A. B. Kempe, B.A.*

bed by the contributor in a paper published in the "Proceedings of il Society," No. 163, 1875, and entitled, "On a General Method of cing exact Rectilinear Motion by Linkwork," which points out the principle on which the linkworks depend. The linkwork No. [8] overed by M. Peaucellier in 1864, and No. [13] by Mr. Hart in 1874; were discovered subsequently by the contributor.

ngths of the links will be found marked on them, and the points ive rectilinear motion are denoted by stars.

). **The Sylvester-Kempe Parallel-Motion.** Model of ork for effecting the exact rectilinear motion of a point. *A. B. Kempe, B.A.*

ered simultaneously by Professor Sylvester and the contributor in he main portion of the apparatus consists of a linkwork of four bent d a "Quadruplane," which is such that four points, one on each rod, e at the angles of a parallelogram of constant area and angles. Two ints consequently are situate at such distances from a third that the nce is the inverse of the other. One of the points being fixed, s made by means of a link to move in a circle passing through the nt, the other then describes a straight line. If the bent rods are aight, the four points lie in a straight line, and the parallel motion that of Mr. Hart, No. [13].

:. **Model of a Linkwork,** by which two rods may be rotate about different parallel axles with equal velocities ary directions. *A. B. Kempe, B.A.*

od the four following linkworks are described by the contributor in ssenger of Mathematics," No. 44, 1874.

l. **Model of a Linkwork,** by which two rods may be made e about the same axle with equal velocities in contrary ns. *A. B. Kempe, B.A.*

:. **Model of a Linkwork,** by which rods may be made to ibout the same axis with velocities proportional to 1, 2, The linkwork can also be used to divide angles into a of equal parts. *A. B. Kempe, B.A.*

, **Model of a Linkwork,** by which two rods, otherwise y be made to remain always in the same straight line with ier. *A. B. Kempe, B.A.*

;. **Model of a Parallel Ruler.** *A. B. Kempe, B.A.*

l. **Model of a Parallel Ruler.** *A. B. Kempe, B.A.*

529i. Link Motion. *William Howe, Chesterfield.*

The sketch was made by W. Howe, in August 1842, which was the first sketch of the shifting link motion. The small rough wooden model was begun by William Howe, in or about 1838, at the Vulcan Foundry, near Warrington, Lancashire, where the sectional cylinder, piston, valve, and foundation frames were made, but this was not for the purpose of applying the link motion, but a tappet motion. When the sketch referred to above was made, the link motion was applied to that model, and all the parts of the old model that could be brought in were used. The model of the twin bar link was designed, in 1848, by William Howe and Mr. William Usher, who was on a visit to William Howe at the time he made the model.

76c. Instrument, with joint, which makes its upper part moveable in a horizontal plane.
Professor Tchebichef, University of St. Petersburg.

76d. Model of joint, which directly transforms a reciprocating into a circular motion.
Professor Tchebichef, University of St. Petersburg.

530. Drawing and Model of a connecting motion between two shafts turning in reversed ways. *Charles Bourdon.*

530a. Four Models, for the description of tooth-profiles, and lines of contact.
Royal Rhenish Westphalian Polytechnic School at Aix-la-Chapelle.

Model No. 1 illustrates the construction of *general* toothing, according to Reuleaux's method.

Model No. 2 shows that by the describing point of a string which run over two rollers, two evolvents constantly coming in contact are marked relatively to them, which for this reason are tooth-profiles correctly workin together.

As the same profiles are described when the axes are distanced from brought nearer to each other, it follows that evolvert-wheels may alter t distance of their axis notwithstanding the correct contact.

The top circles "K" and "K_1" cut off from the "*contact line*" *a b*, *contact space* PP.

Model No. 3 shows that at the *cycloid toothing*, the "*contact space*" sists of the curves (segments) cut off from the head circles, and that normal placed on the tooth-profile in the common point of contact of teeth always passes through the point of contact of the two dividing circ

Model No. 4 evolves spontaneously the circumferential line of the po smallest space between the profiles.

530b. Model of Weston's Differential Pulley, weights complete.
Polytechnic School at Halle, Director Koh

IV. PENDULUMS AND GYROSCOPES.

531. Gyroscope. A mechanical contrivance to exhibit the phenomena of rotation, and to show experiments on the deviation of spherical projectiles. *Elliott Brothers.*

532. Foucault's Gyroscope. Ordinary model.
Geneva Association for constructing Scientific Instruments.

532a. Gyroscope, by Foucault. *College of France, Paris.*

532b. Reuleaux's Ball-Gyrometer.
H. Hädicke, Engineer, Demmin, Pomerania.

The object of the instrument is to indicate the rotations made per minute by any rotating body brought into connexion with the same. The number indicated will be read off a dial. As a remarkable peculiarity it may be mentioned that the scale of the dial shows a uniform division, although the position of the balancing balls moving the pointing hand depends—according to a complicated law—on the velocity of the rotation of the spindle (shafts).

The motion is worked by means of straps and strap disc, and can, as a matter of course (on vessels, &c.), be effected by a fixed connexion with a shaft-movement.

A winch-handle, however, will enable the spectator to put the instrument in motion by the hand.

The accuracy of the indications of the instrument will be augmented if the pointing hand is turned off a little with the finger in the direction of the progressive numbers, and then allows it to jerk back freely.

A forcible turning of the pointing hand in the opposite direction, toward O, is not allowed.

533. The Polytrope. A gyroscope mounted on circles so as to prove the laws of combined rotations about several axes. It may be used to determine the *meridian* or the *latitude* of a place, and to show the rotation of the earth on its axis, and for other experiments.
Wheatstone Collection of Physical Apparatus, King's College, London.

534. "Soldier Experiment." Model designed to demonstrate the relative effects of revolution and of rotation, separate or combined, by the movements of soldiers.
Henry Perigal, F.R.A.S.

535. Compass Experiment, demonstrating that a magnetised needle does, but an unmagnetised needle does not, maintain its parallelism while revolving or orbitating in a circle.
Henry Perigal, F.R.A.S.

536. Gyroscope, demonstrating the effects of revolution and of rotation, the two ways of turning round.
Henry Perigal, F.R.A.S.

5. With this apparatus an infinite number of combinations can be demonstrated. I will mention only four:—

a. Two vibrations of the same amplitude and velocity, no difference of phase. The middle ball has double the amplitude.

b. The same, the difference of phase being 180°. The motion of the middle ball is nearly zero. The deviation that will appear results from the difference in the length of BD and CD (Fig. 1).

c. Combinations of a tone with one of its harmonics 2 and 3 with its quint $\frac{3}{2}$, or its quart $\frac{4}{3}$, as well as when they are of the same intensity or not (theory of the timbre).

d. Combinations of two tones of the same intensity, with the interval $\frac{16}{15}$, showing the origin of beats.

541. Apparatus, of a new form, to illustrate **Wave Motion.** *C. J. Woodward.*

This apparatus consists of a series of balls suspended from a horizontal beam by strings. These balls rest against a series of partitions in a wedge-shaped horizontal trough, which can be raised and depressed parallel to itself. The box, being drawn on one side in the plane in which the balls hang and then slowly depressed, the balls will be successively liberated, and a wave, similar to that of the sound wave, produced. If the beam be drawn aside prior to depressing the box, the balls will rest against one side of the trough and can be liberated in succession, causing them to oscillate in a plane at right angles to the beam, a vibration being produced similar to that of plane polarized light.

541a. Wheatstone's Apparatus, for illustrating the composition of rectangular vibrations. *Council of King's College.*

542. Drawings of new Apparatus for demonstrating the composition of **Vibrations.** *Dr. Leopold Pfaundler, Innsbruck.*

Plate I. Two blackened glass discs are each placed on a separate horizontal axis one before the other, in such a manner that the transparent curves apparently cut in their periphery, intersect each other at nearly right angles. A reflection of light is produced thereby, which, at the revolution of the discs, will generate figures such as are caused by the complex effect of the vibrations acting at right angles upon one another. By a simple mechanical contrivance the velocity of the rotary motion of each of the discs can be regulated according to equally simple relative relations. Thereby the figures of the different intervals are produced. By varying the tension of the strings more or less, an alteration in these places will be achieved. By changing one or the other of these discs, and replacing it by another with a different curve, the figures observed by Professor Dr. Helmholtz, on oscillating strings with the vibration microscope, will be obtained, instead of those of Lissajous.

Plate II. Two thin rods of steel are fastened by screws at the two oblique corners of a strong bar of iron in such a manner that their further ends, one reaching above the other, vibrate vertically the one upon the other. To these ends small metal plates (discs) with incised slits are attached in a parallel position. The reflection of light produced by the intersection of these slits will show Lissajous' figures. A movable weight regulates the intervals.

B, the well known *tuning-fork apparatus* with mirrors is simplified by the tuning-fork being replaced by steel springs which are inserted in suitable movable wooden columns.

Plate III. Apparatus for simplified demonstration.

A. ramified tuning-fork.

The same produces a sound composed of two tones, and marks the corre-onding musical note direct on a sooty glass plate.

B, resonator with monometrical flame without membrane.

In a conical shaped Resonator, which is held with the large opening down-ırds, illuminating gas is filled from the top, which is allowed to escape through attached small tube and then ignited. The flame will react on the tones ounds) in the usual manner.

C, an igneous Kaleidophon.

Mr. Assistant Tollinger has shown that by fastening with wax a glimmering ındle to the end of a prismatic steel spring, a very commendable demon-ration for large auditories can be produced of this well-known experiment.

542a. Apparatus for **combining waves** in one plane. The sultant shown is that of two sets of waves (superposed) that iffer by half a wave-length. *Chas. Brooke, F.R.S.*

542b. Apparatus for **combining waves** in two planes per-ndicular to each other. The resultant shown is a right-handed liptic helix. *Chas. Brooke, F.R.S.*

543. Stationary Liquid Wave Apparatus and Sector endulum. *Frederick Guthrie, F.R.S.*

When such a system of stationary waves is formed in a cylindrical deep ough that the centre rises and falls as the edge falls or rises, the undu-tion is synchronous with a pendulum whose length is equal to the radius of e trough; and the accelerations of motion of the wave and pendulum are lentical.

544. Wheatstone's Wave Apparatus. A very complete ıstrument, showing plane, circular, and elliptical waves, the henomena of interference, &c. *Elliott Brothers.*

544a. Apparatus to illustrate **Wave Motion.**
Rohrbeck and Luhme, Berlin.

545. Illustrations of Vortex Motion. Nos. 1 and 2 are ibrations; Nos. 3–5 steady motion. (Proceedings of Royal Society of Edinburgh, 1 November 1875.) *Sir William Thomson.*

Series of 11 successive figures of a simple vortex ring, performing violent transverse vibrations of the first fundamental mode.

No. 2. Series of 11 successive figures of a simple vortex ring performing violent transverse vibrations of the second fundamental mode.

Motion analogous to that of screw propellers backing the vortex cone, being in each instance as it were the edge circumference of the screw propeller.

No. 3. Two-bladed screw.

No. 4. Three-bladed screw.

No. 5. Four-bladed screw.

No. 6. Trefoil knot described in Sir W. Thomson's papers on vortex motion. Transactions of Royal Society of Edinburgh for 1857 and 1858, and figured on the back of the "Unseen Universe," by Professors P. G. Tait and Balfour Stewart.

VI. FALLING BODIES AND PROJECTILES.

546. Drawing of a new Apparatus for demonstrating the lateral deflection of rotating conic projectiles.

Dr. Leopold Pfaundler, Innsbruck.

The conic projectile A turns within the horizontal frame B on its own horizontal axis, and can be put in rotation by pulling off the reel the string attached to *a*. Fastened, on the outside of the frame, on two little hooks, *b*, *b*, whose line of communication is perpendicular to the axis of rotation and passes through the centre of gravity of the entire body, are two threads, which join further up, and whose combined continuation reaches up and is tied to a hook in the ceiling.

At the back there is a steering wing C with a counter-weight D, attached in such a manner that according to the position in which it is placed the effect of the atmospheric resistance will be located either above or below the centre of gravity of the projectile, without, however, altering the position of the centre of gravity itself. The wing can be turned on its axis, or be removed and replaced by a double wing C¹ with the two flat surfaces situated vertically to each other.

The following experiments can be made with this apparatus :

1. *Stability of the Axis of Rotation.*

The apparatus is put in motion to swing in a curve of five meters length by taking hold of the wing and pulling it backwards, and then allowing it to drop. If the projectile does not rotate, it easily turns over and will deviate from its course by very slight causes; if it rotates, it will remain parallel with its axis. The wing must be given a neutral position in regard to the atmospheric resistance.

2. *Lateral Motion.*

The apparatus is made to rotate to the *right* by the wing C being placed in an *upward* position, when the point in flying forwards will revolve to the *right*. If the direction of the rotation, or the position of the wing, be altered into the opposite course or direction, the point will revolve towards the *left*. If both are changed, the rotation will keep in the direction to the *right*.

3. *Lateral Deflection.*

The single wing C is replaced by the double wing C¹, the flat surfaces of the same being placed in a vertical and horizontal position, and the proceeding then is the same as described before.

Instead of the lateral motion, a parallel lateral deflection will be the result.

The latter experiment corresponds to the actual motion of the projectiles. The greater degree of velocity of the same is equalised by the larger surface of the wing as regards the atmospheric resistance.

547. Simple and Inexpensive Form of Morin's Machine for demonstrating the law of falling bodies. It can be made by an ordinary carpenter, at a moderate price.

Made and exhibited by Dr. Stone.

548. Apparatus by General Morin for the experimental demonstration of the laws of falling bodies.

M. Digeon, Paris.

549. Attwood's Machine with water clock attached.
The Council of the Yorkshire College of Science, Leeds.

The time is measured by a water clock, the orifice of which can be opened by eans of a lever moving under the influence of an electro-magnet. The weights :e supported by a thread grasped by a pair of iron pincers, which are kept shut y a spring, but can be opened by means of another electro-magnet included in ie same circuit as that attached to the water clock, so that the water begins › flow and the weights to fall simultaneously. Another metal piece can be crewed on to the instrument. One of the binding screws with which it is ırnished is insulated from it by a plate of ebonite pierced with a shut metallic od in connexion with the binding screw, and on which rests one extremity f a lever in electric communication with the rest of the piece. This iece being included in the circuit the current cannot pass when the lever is aised, and the water clock is stopped as soon as this is effected by the falling reight.

549a. Attwood's Machine, with friction rollers and electro-ıagnetical release. *Ferdinand Ernecke, Berlin.*

549b. Attwood's Machine, with pendulum attached.
Rohrbeck and Luhme, Berlin.

VII. FRICTION.

550. Apparatus for determining the Friction between Water and Air.
Professor Viktor von Lang, Vienna University.

The above consists of a heavy stand with one fixed and three movable arms. The fixed arm bears a short glass tube, from which a continuous stream of water is made to flow. A crosspiece of four glass tubes is united, air-tight, by its longest arm to the water-delivering tube; the opposite arm is directed downwards, and closed by a caoutchouc mouthpiece passing over the "aspirating tube." This latter is supported by the two lowest arms of the stand, the remaining fourth arm securing the crosspiece. The stream of water passing through the "aspirating tube" moves the air, the quantity of which is determined by the motion of a soap lamina in the "measuring tube." This tube is joined to one of the horizontal arms of the crosspiece, the fourth arm bearing a water manometer.

550a. Machine for the **Examination** and **Measurement** of the **Sliding Friction** caused by the **Motion** and the **Variable Velocity** on **Rails.** Constructed by Herr Jung, at the University of Giessen.

This machine includes :—

a. A board, with hooks for attaching a scale by means of a cord running on a roller, for the purpose of measuring the friction.

b. Two pairs of iron and brass rails, to be fixed to this board.

c. Three pairs of wooden rollers.

d. A pair of iron rollers.

e. A pair of brass rollers.

Institute for Physical Science of the University of Giessen; Professor Dr. Buff.

This apparatus was originally used for measuring gliding friction. It is at the same time a convenient appliance for demonstrating the friction of the steam engine on the railway line.

SECTION 5.—MOLECULAR PHYSICS.

WEST GALLERY, UPPER FLOOR ROOM (Q).

I. SPECIAL COLLECTIONS.

DARDS OF THE HYDROMETERS AND THERMOMETERS USED BY GOVERNMENT OFFICERS IN HOLLAND.

hited by Dr. J. W. Gunning, Professor of Chemistry at the "Athenæum illustre," Amsterdam.

9. **General Hydrometer** (No. 1), with open stem and le weight. Every degree has a bulb equal to $\frac{1}{100}$ of the part hydrometer below zero. When this instrument, having the ary weight = W, marks *a* degrees in a liquid, the apparent ic gravity of that liquid at the observed temperature will

$$\frac{W}{(100 + a)1{,}014{,}608.}$$

0. **Instruments** (Nos. 2 and 3) for ascertaining the strength oholic liquors. The degrees are the same as in No. 1, but the t is not variable, and the zero is the immersion.point at . in a liquid, of which the specific gravity at that temperature al to the specific gravity of pure water at 4° C. Tables are , those of Professor von Baumhauer (1863), used in Holland ; of the exhibitor (1873), used in the colonies. The latter are on the researches of Mendelejeff. Philos. Mag. (4) XXIX.

1. **Hydrometer** (No. 4), for liquids of a specific gravity er than 1. The construction is the same as in Nos. 2 and 3. Beaumé scale is added. Used for solutions of salts and sugar

2. **Hydrometers** (Nos. 5 and 6), for ascertaining the ic gravity of seed oils and of petrol, allowing immediate ation of correction for temperatures, other than 15° C. (For ption see Scheik. Bijdragen door J. W. Gunning, Amster- 1867.31.)

3. **Densimeters** (Nos. 7, 8, and 9), with flat stems. The s the same as in Nos. 2 and 3.

Naturalis," which was published at Leyden in the year 1685. In his w "Rationis atque Experimenta Connubium," which was published at Rotter in the year 1715, he states that he made the invention in 1675, and tha 1679 he had the air-pump executed by a skilful artisan. That this artisan *Samuel Musschenbroek* is proved by a notice in the handwriting of *Petrus Musschenbroek*, which he wrote in a copy of his work entitled, "Beginse der Natuukunde." However, *Senguerd*, in the first edition of his w "Philosophia Naturalis," which appeared in 1680, and of which a copy i the possession of the Library of the University at Utrecht, makes no m tion yet of the cock. He has therein an illustration of an air-pump of original construction of *Otto von Guericke*. That, however, the air-pump constructed is plain, by a record of *Uffenbach's*, who, in describing "Laboratorium Phyricum" of the University of Leyden, stated on the 1 January 1711:

"In the centre stood also an elevated table. Upon this table there stood 'Antlia pneumatica' of considerable size, of *Samuel Musschenbroek's* invention, inclined with a 'cista' to put water in." Although the wo "of the invention of *Sam. Musschenbroek*" may also be applied or h reference to the air-pump, which is still preserved in the Physical Scie Cabinet at Leyden, yet the description does not tally with it, inasmuch its cylinder is perpendicular, and stands next to an elevated table wh carries the plate, and is consequently united with it in one apparatus. It possible that *Uffenbach*, who was not an adept in that science, was only indu to making the above-mentioned expression by the sign of the firm of *S. Musschenbroek*. But how it happened that he did not see the other air-pum since he mentions yet another still existing air-pump of *Boyle's* constructio is rather obscure, as *De Volder*, *Senguerd's* predecessor in the professorship physics at Leyden, who himself has laid the first foundation for the establis ment of the Physical Science Cabinet at Leyden, must have worked in t same laboratory. "As we were assured," continues *Uffenbach* in his narrative "there are given here (in the laboratory) 'Lectiones publicæ' four times "week by *M. Senguerd*, *De Volder*, however, it was stated, has had mo "auditors, as he was also more artful ('curieuser') in his experiment."

Senguerd delivered those lectures not until after *De Volder's* retiremen in 1705. *De Volder*, however, died in 1709, and it is possible that the ai pump was at that time in course of reconstruction. *Senguerd's* air-pum therefore, as it is not to be found in the Physical Science Cabinet at Leyde must, in all probability, have been private property; and it is possible tha like many old instruments, it is still somewhere in private possession in Ho land. So long, however, as it is not discovered, the Museum at Cassel m lay claim to the distinction of having in its possession the air-pump with th oldest doubly-perforated stop-cock. For although *Senguerd* had his ai pump made in 1679, the description of the same did not appear until 1685 which indeed excited much attention at the time. Christian Wolff, in 1718 had one constructed exactly according to the same pattern, by Leupold Leipsic, which may still be seen in the Physical Science Cabinet of the Uni versity at Marburg. Very singular indeed it is that Musschenbroek, in hi manifold writings, never as much as mentions Senguerd's air-pump. Tha of course, this omission cannot be constructed into an argument as again the priority of *Senguerd* is plain by the subsequent remarks in the above mentioned autograph notice, in which it is stated that "in the year 167 "*Mr. Senguerd* considered with the same *Samuel Musschenbroek* air-pump "of another kind, which afterwards were improved by my father, *Jan va* "*Musschenbroek*, as well as by my brother" ("in den jaare 1679 heeft d "Heer Senguerd met dienzelven *Samuel Musschenbroek* hucht pompen va "een anderen aart bedagt, welke geduurig naderhand door mynen vad

"Jan van Musschenbroek, als door mynen broeder verbeterd zyn.") It seems as if family partiality had influenced him.

The air-pump is accompanied by two powerful Magdeburg hemispheres with which at Cassel the experiments of Otto von Guericke, of the Regensburg Diet, were repeated.

604. Compression Machine.

The Royal Museum at Cassel, Dr. Pinder, Director.

The Compression Machine for throwing bomb shells (air-mortars).

This is one of the most ancient instruments that are in the possession of the musem at Cassel. On the 16th November 1709, already von *Uffenbach* had seen it in the Art Museum of Landgrave *Karl*. It was to serve for the purpose "of throwing grenades, when already lighted, through the air for a "distance of more than a 100 yards, with the usual effect." At that time it had just been repaired of some of its former defects. "Twelve grenades can "be thrown one after another with great rapidity. But, because as the air is "continually diminishing, the last ones, as may be easily conceived, do not "go as far as the others." This instrument, which acts on the principle of an air-gun, and by which also red hot shots could be thrown without any danger to the men serving it; the brass ball carried a funnel upon which the grenades were placed—is so far of historical interest as it is a surviving witness of the joint labours of *Papin* and the Landgrave *Karl*, and it even transports us in the midst of that catastrophe, which put an end to Papin's activity. A similar machine, with which *Papin* contemplated throwing bomb shells by means of steam, it was which exploded in his laboratory. "The other and "greatest misfortune was that, as he had undertaken to shoot the same with "water as with powder, he might easily have done great mischief, for as the "machine prepared for that purpose exploded, not only a great part of the "laboratory was demolished, several men mortally wounded (one among "whom had his jaw-bone carried away), but even Landgrave Karl himself, "who is a very curious lord, intent upon seeing and examining everything "minutely, might have been hit, and have lost his life, if not His Highness had "been detained by mere accident by other affairs and come to the laboratory "later, on which occasion Papin was dismissed from his service."

605. Suction Pump, on an iron stand.

Ferdinand Ernecke, Berlin.

605a. Suction Apparatus. Two small pieces of apparatus to illustrate the deficiency of pressure attending a high velocity in a stream of air. *Lord Rayleigh.*

By blowing through the electrotyped copper tube a suction of 6 inches of mercury may be realised at the narrow part.

In the second arrangement the novelty consists in the cap at the end of the brass tube, by which the efficiency is increased.

607. Two large Magdeburg Hemispheres of copper.

Professor Dr. H. Weber, Brunswick.

The two large hemispheres of copper are those of which *Otto von Guericke* states, in page 104, Tab. XI., that after their evacuation they could not be separated by the united strength of 16 horses. They have a diameter, as mentioned in the work alluded to above, of nearly $\frac{3}{4}$ Magdeburg ells, or, according to a second more exact statement, 0·67 Magdeburg ells.

The two smaller hemispheres of brass were used for experiments with weights (page 106, Tab. XII.).

608. Two smaller Magdeburg Hemispheres of brass.

Professor Dr. H. Weber, Brunswick.

branes or porous plates, whose electric osmotic permeability is to be compared, are placed between the cell and the glass vessels, the whole secured by two brass vices. Both vessels and the cell are now filled with the same fluid. Non-elastic partitions (clay plates, f. i.) must, in order to prevent breakage and leakage, be provided, on each side, with an elastic ring (india-rubber or bladder).

Thin, very pliable, membranes f. i. skin of a frog, are secured between sieve-like perforated plates of ebonite to prevent bending.

The apparatus is used to demonstrate:

1st, the fact of electric osmosis.

2nd, the specific influence of the membrane; the rise and fall of the fluid in the cell shows which of the two membranes possesses a greater electric osmotic permeability. On removing one of the partitions, the apparatus becomes an ordinary osmometer.

(Onderzoekingen gedaan in het physiologisch laboratorium der Utrechtsche Hoogeschool. Derde Reeks, II., 1873, p. 365, etc.)

632. Osmometer, illustrating the transpiration of gases through capillary tubes. *Prof. W. F. Barrett.*

This is an apparatus constructed under the direction of Professor Sullivan for illustrating the law of the transpiration of gases. The diaphragm is made of a number of short lengths of capillary tubes.

IV. CONDENSATION AND SOLUTION OF GASES.

633. Adams' Apparatus, for condensing and solidifying carbonic acid. *William Sykes Ward.*

634. Apparatus used in 1857 for Liquefying Ice by Pressure at temperatures below 150° C.

Prof. Mousson, Zurich.

A small cylindrical recipient, hollowed out of a strong piece of steel, is filled with water containing a movable metallic index. When the water is frozen, the recipient is closed by means of a soft copper cone, subject to the action of a strong screw. The apparatus is then *reversed.* The recipient merges into a long, slightly widening cone of soft copper, on which a short steel rod presses by means of a powerful screw-nut acting on the principal piece, and a double lever a metre in length. If the recipient be opened, after the pressure is removed, the index is found to have been carried over to the other end, as a proof that the ice has been reduced to a liquid state. Soft copper is the only means of closing under excessive pressures.

The experiment can be successfully made at 18° C.

635. Original Model of the Capillary Tube of Messrs. Poncelet and Lestros. *Conservatoire des Arts et Métiers, Paris.*

636. Original Thilorier Apparatus for liquefying carbonic acid, 1857. *Conservatoire des Arts et Métiers, Paris.*

637. Apparatus for illustrating Boyle and Marriotte's law to a class. *Prof. W. F. Barrett.*

The mercury contained in the upper iron reservoir can be admitted to the tube through an aperture closed by a valve that is moved by pulling the string.

: is kept level with the air chamber. Equality of pressure with the re is readily obtained by means of the stopper closing the lower or air chamber.

Compression Pump and Receiver. An apparatus r and solidify gases.

H. Lloyd, Trinity College, Dublin.

Apparatus employed in the researches of Dr. Andrews ontinuity of the gaseous and liquid states of matter, and roperties of matter at high pressure and varied tempera-

Dr. Andrews, F.R.S.

paratus consists of two cold-drawn copper tubes of great strength, ating by horizontal passage, and having massive end-pieces above , firmly bolted on with interposed leather washers, so as to be able ay pressure. The upper end-pieces are traversed by fine glass tubes, on between the glass and metal being made tight by a peculiar conical packing. The exposed parts of the glass tubes have a ore, and, if sufficiently fine, will bear a pressure of 500 atmospheres ithout bursting. One of the tubes contains air or hydrogen, and manometer, the other contains the gas or liquid to be examined. end-pieces carry well hacked steel screws, which produce the pres- npressing the water with which the apparatus is filled. The tem- f the air or hydrogen in the manometer, and that of the gas or er examination, can be varied at pleasure by enclosing the glass ater cylinders of glass, or, where accurate readings are required, in ar vessels with plate-glass sides. With this apparatus, accurate ents can be made to 500 atmospheres, or even higher pressure, and ;ht modification, at any temperature which glass will bear without

Single Apparatus, adapted to exhibit the properties of . liquids under different conditions of pressure and tempe- it without measuring the pressures employed.

Dr. Andrews, F.R.S.

paratus is similar in construction to the compound form last

Original Apparatus, by Desprey, by the help of : proved the difference, shown by gases, in relation to the ariotte. *The Faculty of Sciences, Paris.*

Original Apparatus, by Gay Lussac, for ascer- e elastic force of gases and vapours.

Polytechnic School, Paris.

Apparatus, by M. Dumas, for illustrating the density s. *Conservatoire des Arts et Métiers, Paris.*

Sulphurous Acid Tube, to exhibit the flickering striæ ur from slight changes of pressure near the critical point ature. *Dr. Andrews, F.R.S.*

658. Clark's Import Hydrometer (obsolete). Formerly used for ascertaining the strength of spirits imported.

Dring and Fage.

The same in principle and construction as the one for export, only having nine extra or intermediate weights, called per cent. weights. This class of instrument was only used for determining the strength of spirits imported, and was adjusted slightly in favour of the importer.

659. Set of Six Twaddell's Hydrometers. Used for ascertaining the density of solution; principally used in trades for which no special instrument of the kind is constructed.

Dring and Fage.

The divisions on these instruments are so placed as to indicate equal differences of gravity. The specific gravity of a fluid is formed from the indication of this scale by multiplying by 5, cutting off 3 decimal places, and prefixing unity.

655. Specific Gravity Instruments, for testing liquids from 650 to 900 spec. grav. *L. Oertling.*

659a. Fahrenheit's Metal Hydrometer.

The Physical Science Laboratory of the Technological Institute at St. Petersburg (Russia).

The theory of this instrument has been described and illustrated by an example by E. Lenz, Academician, in the "Bulletin physico-mathématique "de l'Académie des Sciences," Vol. XV., 1857.

660. Thermo-Dilatometer, by Baudin, showing the strength of alcohol in 100ths. *M. Baudin, Paris.*

661. Thermo-Dilatometer, by Baudin, showing the alcoholic strength of wines and other liquids.

(The last two instruments are the property of the "Conservatoire des Arts et Métiers.") *M. Baudin, Paris.*

662. Dring and Fage Saccharometer, for ascertaining the density of brewers' worts. *Dring and Fage.*

Used for determining the density (in pounds weight) of a barrel of wort, of 36 imperial gallons, in excess of the same quantity of distilled water at a temperature of 60° Fht. The rule accompanying the instrument shows the weight of the residuum if a barrel of wort were evaporated to dryness; also the amount of proof spirit to be obtained, and the specific gravity.

This instrument was the joint invention of Messrs. Dring and Fage, and perfected by the valuable experiments and calculation of Dr. Hope Coventry and Thomson.

663. Quin's Saccharometer. (Obsolete.)

Dring and Fage.

664. Dring and Fage Still, for ascertaining the original gravity of a wort from a sample of beer. *Dring and Fage.*

Used by the Excise and Customs when making the allowance for drawback on export beer.

664a. Apparatus by Rakowitsch for testing **Alcohols** and **Saccharine Matter** in **Liqueurs;** likewise for ascertaining the fatness of butter, and for testing water.

R. Nippe, St. Petersburg.

665. Apparatus for determining the Specific Gravity of bodies, inclusive of a thermometer.

Ch. F. Geissler & Son, Berlin.

670. Parabolic Diagram of the relation between tension and volume of the saturated steam.

H. Hädicke, Demmin, Pomerania.

This parabolic tension diagram shows that it is justifiable to replace Mariotte's oder Pambour-Navier's tension-lines of the saturated steam by a parabola. This method gives for the ratio of the mean pressure (p_0) on one side of the piston to the absolute pressure at the commencement (p), and the cut off (ϵ) the elementary formula : $p_0 = p - \frac{1}{6}(1-\epsilon)^2(4p+1)^2$, or $\epsilon = 1 - \frac{\sqrt{6(p-p_0)}}{4p+1}$.

(See "Practical Tables and Rules for Steam Engines," by H. Haedicke Kiel, 1871.)

671. Piknometer. *Dr. H. Geissler, Bonn.*

672. Two Sets of Areometers. *Dr. H. Geissler, Bonn.*

673. Manometer for Minute Observations, used by A. de la Rive in all his latest researches concerning the propagation of electricity in rarefied gases.

De la Rive Collection, the property of Messrs. Soret, Perrot, and Sarasin, Geneva.

This instrument, constructed by the Geneva Association for the Construction of Scientific Instruments, consists of two glass tubes dipped in a common mercury trough, of which one is a simple locomotive tube serving as a point of comparison, the other communicating on its top with the quantity of rarefied gas by means of a pipe adjusted in the setting of the apparatus. The pressure, that is, the difference between the two mercury columns, is read by means of a small cathetometer, of which the millimetric graduation is turned towards the tubes and the lamp which lights them both. This graduation is reflected in the telescope by means of a full reflecting prism placed before the objective. Thus the level is at once read, and a micrometrical division placed at the focus of the eye-piece shows the $\frac{1}{25}$ of the millimetre.

673a. Delicate Pressure Gauge.

Dr. K. List, Hagen, Westphalia.

The very light pressure required to produce a current through the stoves can be shown by the delicate pressure gauge (enclosed in a mahogany case), which has a thin diaphragm exactly one square foot in area, and has a light lever and weights to cause it to bear the pressure brought on its surface, so that the whole pressure of the air on one square foot is exactly weighed with ease. As small a pressure as one hundredth of an inch of water can be measured.

Alcoholometer, consisting of two cylinders of eboni
ss, keyed together. *G. Recknagel, Kaiserslautern*

:oholometer is not liable to break, and answers all requirements o
in reading.

Areometer of ebonite and brass, with adjustable cylinder.
G. Recknagel, Kaiserslautern.

ot being liable to be broken can be used for educational purposes as
or practical application.
pper terminal level plate is adapted for placing small weights on it,
of which the meaning of the dividing lines can be demonstrated.
ument, moreover, is arranged with a *cylindrical slide*, which can be
to the double volume of the divided spindle. If the scale is ex-
the slide is to be pulled out a volume more, and the scale is then again
al for use.
ost suitable for instruction and practice is the uniform scale of the
ac areometer. As, however, there is easily room for four scales, the
n be arranged for direct indication of specific weights, or, like the
odels, for alcoholometry.

Areometer Case, containing three standard areometer-
s, for determining the specific gravity of all kinds of
with indicator scale fused to them. *W. Zorn, Berlin.*

Areometer. The indicator scale is not fused into the
ut fastened only with sealing-wax. *W. Zorn, Berlin.*

f these areometer-cases contains three glass spindles, which, loaded
in a similar manner to Nicholson's metal spindles, with weights,
ith the greatest accuracy the specific weight of *all* liquids.
id to be tested must be brought to a temperature of 15° Celsius; if
spindles is inserted in the liquid, so many weights must be placed
plate as are required to make the spindle sink as far as the black
milk-white glass line in the neck of the spindle.
est spindle embraces all liquids from 0·650 to 1,000; if this
d, 0·650 must be added to the weight placed on the spindle. If
(1,000) spindle has been employed, 1,000 must be added to the
the heaviest (1,400) spindle, 1,400 must be added to the weight
same. The sum obtained will give the specific weight of the
accuracy extending a little over the third decimal.
the correctness is simple; it is only necessary to have a good
nd some distilled water:
0 weight = spindle 0·650; spindle 0·650 +
0 weight = spindle 1,000; spindle 1,000 +
0 weight = spindle 1,400.
n of these areometers is *new*. For many years the exhibitor
milar areometers, consisting, however, of two spindles only,
nuch liked, under the name of Wittstock's areometer, on
curacy; but it was too fragile, owing to the light spindle
ng but two of them) having to carry too much weight.
Privy Councillor, Dr. Wittstock (apothecary to the Royal
d devised a peculiar proportionate weight to the same,
lles had derived their name, but which is now no longer

apparatus is composed of two plates, superposed, and perfectly l, between which is introduced a pressure of air or gas. The air, ng from the centre between the two plates, bears upon these a pressure d by its elastic force and by the extent of the surfaces brought into t contact. When this pressure equals or exceeds the weight of the cted upon, this is upheld in the air, where it becomes subject to extra- r mobility. Having no longer any weight, the friction which is pro- d to weight is annulled, and the resistance no longer depends on that y scarcely yet studied, the viscidity of the air.

l. Rotation Apparatus for determining the effect tmospheric Resistance on bodies of different shapes, larly on projectiles. Constructed by Theodor Baumann, , Mechanical Engineer, Berlin.

Professor Dr. E. E. Kummer, Berlin.

" Abhandl. der Königl. Akademieder Wissenschaften in Berlin, ; " Über die Wirkung des Luftwiderstandes." by E. E. Kummer.

'. Two Apparatuses for measuring the Transpira- f Air at different Temperatures.

Dr. O. E. Meyer, University of Breslau.

cribed in "Poggend Ann., 1873," vol. 148, p. 203.)

:. Apparatus to illustrate to a large audience the fact ie **pressure** exerted by a **curved liquid** film increases he **curvature.**

apparatus consists of a glass tube communicating with two others, which is furnished with a stop-cock. Bubbles of different diameters rn at the ends of the tubes, one stop-cock being closed while the other , and then communication with the outer air being cut off, and the th opened, the smaller bubble is seen to diminish and the larger one ise, thus proving that the air inside the smaller bubble was the more sed. The tubes are bent, so as to bring their extremities close , and the experiment can be shown to a large audience by throwing a d image of the bubbles on a screen.

. Apparatus for demonstrating **Leidenfrost's phe- non of drops.** *Dr. J. Hoogewerff, Rotterdam.*

apparatus was constructed by Mr. Kellenbach, curator of the Batavian at Rotterdam, and belonging to the academy of plastic arts and tech- iences at Rotterdam. The apparatus is used as follows: A Grove connected with the instrument, a galvanometer being placed on the ing wire, and the copper tray or platinum capsule into which the f water have been put, are heated by means of a gas lamp. Every idenfrost's experiment is repeated, no current is indicated by the gal- ter, contact having been interrupted by the layer of steam; when on trary the water, the surface of which is in contact with the copper mes into immediate contact again with the metallic surface of the capsule, the galvanometer distinctly indicates the current.

3. Apparatus for determining the **Tension** of the **Vapours** ferent liquids at the boiling point. *Prof. W. F. Barrett.*

common form of apparatus. The liquids whose tensions ... l are inserted in the barometer tubes, and either ste... the vapour of some liquid having a lower boiling point, such as alco... sent through the larger tubes.

686a. Apparatus for illustrating the **Tension** of **Vap...** at or below the freezing point. *Prof. W. F. Ba...*

687. Diagram of Torricellian Vacuum. 1644. *A. Galletly, Edinb...*

687a. Independent ... Plate for **Pneumatic Machi...** *Geneva Association for Constructing Scientific In...ments.*

This plate is made entirely of cast-iron, as well as its stand, so as ... become damaged in experiments where mercury is employed.

687b. Sir Humphery Davy's Laboratory Note Bo... *Royal Institution of Great Br...*

Davy's record of his decomposition of potash by the voltaic b... October 19, 1807.

687c. Faraday's Laboratory Note Book. *Royal Institution of Great Bri...*

Faraday's record of his condensation and liquefaction of gases, Mar... 1823.

SECTION 6.—SOUND.

West Gallery, Upper Floor, Room (Q).

I.—SOURCES.

Apparatus used by M. Rijke to cause a tube to emit when wire gauze placed in the interior is heated.
Professor Dr. P. L. Rijke, Leyden.

Whistles for producing shrill notes, within and beyond :s of ordinary audition. *Francis Galton, F.R.S.*

whistles were designed for testing the limits of the power of men and f hearing very shrill notes. The plugs that close the whistles can :d up and down, and the length of the whistle, and therefore the f vibrations per second, can be ascertained by the attached gradua- he whistles are of three forms : (1) a small cylindrical tube, which ure note, but of small power ; (2) a flat, wide and narrow whistle, of : plug is a broad thin plate of metal; (3) an instrument which is y a cylinder of 2¼ inches in diameter, but of which the effective part · an annulus; the plug of this is a cylindrical sheet of brass; it gives ul note, but not a very pure one.

Brass Tube to sound the constant proper tone of the characterising the vocal sound.
Professor Donders, Utrecht.

onsists of a brass tube ending in a broad slit, at the other end with rubber tube to be placed on a blower "*souffleur*." (Donders.) t, directed by the slit on the borders of the lips, sounds during the rocal sound is sung in different tones, the constant proper tone nouth characterising the vocal sound. (Compare Donders, Uber r der Vocale, Holl. Beit. zur Nat. u. Heilk. 1846.)

Set of Vowel Forks and Resonance Globes.
Frederick Guthrie, F.R.S.

Set of Organ Pipes. *Frederick Guthrie, F.R.S.*

Set of Tuning Forks. *Frederick Guthrie, F.R.S.*

Photograph of a Chemical Harmonica of glass for ies, with eight pipes (major-scale from d^1 to d^2 inclusive), ouble regulating cocks, and key-board for playing. copy of a few melodies executed on the same for two :e voices.
Professor J. Joseph Oppel, Frankfort-on-the-Maine.

The apparatus itself is, on account of its brittlene
The glass tubes can be turned by means of metal
displaced in respect of the height of the flames, the
being regulated by small cocks, and the acoustic
minor accords (particularly when carefully tuned)

695. Diapason Tuning Fork.

695a. Diapason arranged for continuous

696. Tube for Singing Flames, s
gotsch's system.

697. Set of Glass Tubes for illustrat
with paper slider for adjusting the pitch of a

698. Set of Resonant Tubes.

By suddenly and successively withdrawing the st
the air within the series of tubes will give the notes o

699. Apparatus for experiments with si

The above, consisting of glass tubes of similar siz
a revolving mirror, will illustrate most of the ph
harmony, &c.

700. Inferior Limits of Audibility
show the lowest number of vibrations that w

701. Sir Charles Wheatstone's Res

By moving a piston up and down, and thus dimi
resonator, a perfect two-octave scale of aliquot parts
spring, which would otherwise sound but one note.
played as rapidly as by the fingers upon a pianof
vibration by a twang with the forefinger of the left h
with the right hand.

701a. Sir Charles Wheatstone's Rec ment, for rendering the vibrations of rectilin
distance.

Robert Sabine, 25, Cumberland Te

704. Set of five Steel Tuning-forks c

II.—MEASUREMENT.

705. Revolving Drum, for determining pitch of note.
Prof. Frederick Guthrie, F.R.S.

The styles attached to two vibrating forks mark sinuosities on the blackened surface of the drum when it turns and advances on its screw axis. The pitch of the notes is thus compared.

705a. Apparatus, by M. Regnault, for ascertaining the velocity of sound. *College of France, Paris.*

706. Acoustic Apparatus, for ascertaining the velocity of transmission of sound through water, used in 1826 on the Lake of Geneva at a distance of 13,487 metres, and subsequently in 1841 at a distance of 35,000 metres.
Professor Daniel Colladon, Geneva.

Acoustic apparatus used in 1826 and 1841, during a series of experiments upon the transmission of sound through water, and upon the direct measurement of the velocity of sound in the water of the Lake of Geneva.

Mémoires de l'Académie des Sciences de l'Institut de France, savants étrangers, sciences mathématiques et physiques, vol. 5, 267 and following pages. Comptes-rendus de l'Institut, vol. 13, p. 439, séance 23rd August 1841.

N.B.—With this instrument it is possible in calm weather to hear, at the distance of more than a hundred kilometres, the reverberation of blows struck upon a bell of about half a ton weight immersed in the water, and thus to use it as a submarine telegraph, or for transmitting signals in foggy weather.

707. Apparatus for marking Tuning-fork Vibrations.
Professor L. von Babo, Freiburg, Breisgau.

707a. Original Apparatus, by Duhamel, for registering vibrations. *Polytechnic School, Paris.*

708. Helmholtz' Double Siren.
H. Lloyd, Trinity College, Dublin.

709. Double Siren, such as was employed by Professor Helmholtz in his researches on sound.
Prof. Frederick Guthrie, F.R.S.

710. Siren, of card-board, with four circles of holes, 64, 80, 96, and 128, giving major chord. Made by Yeates and Sons.
Prof. W. F. Barrett.

The above is provided with an air-chest and four keys, so that any or all the circles of holes can be made to sound at pleasure.

711. Siren, an instrument for showing the number of vibrations corresponding to a given note. *Elliott Brothers.*

712. Savart's Toothed Wheels. A set of wheels, of different sizes and numbers of teeth, to produce a succession of notes. *Elliott Brothers.*

713. Sonometer, with sound-post on the principle of the violin. Also adapted for passing the galvanic current through strained wires. *Dr. Stone.*

714. Metronome, invented by Dr. Wollaston. *G. H. Wollaston, Esq.*

715. M. Le Roux's Apparatus, for determining the velocity of sound. *Conservatoire des Arts et Métiers, Paris.*

716. Phonometer. *Prof. Lucae, Berlin.*

The phonometer, "speech-scale," is intended to determine accurately the intensity of speech, that is to say, the pressure of expiration employed in speaking.

The apparatus consists of a short metal tube, one end of which expands in the shape of a funnel to a kind of mouth-piece, whose brim is coated with gutta-percha. At the other end of the tube is attached a contact lever oscillating in an axis, the lower section of which lever is formed by a round aluminium plate, which, when in a state of repose, that is to say, at the vertical position of the contact lever, closes the tube, whilst the upper end of the contact lever, terminating in a point, indicates on a quadrant the oscillations of the pendulum. By any word which is spoken into the mouth-piece, the plate will be pressed outwards according to the pressure of the air employed. A spiral spring attached to the axis has the effect, that by discontinuing speaking the contact lever remains stationary in the maximum of the motion transmitted to it, and its inclination can be read on the quadrant. The practical use of the instrument in the first instance is, to determine when speaking in a loud or a low voice the relative intensity of one and the same word, or, rather, the preponderating sound prominent in the word uttered, and imparting to it the greatest colour. This object the apparatus perfectly accomplishes, since the force of the utterance is proportional to the density of the air effected in the tube. The apparatus consequently admits, among other things, of a more exact test of hearing with persons slow of hearing than has been the case hitherto with ordinary speaking.

716a. Phonoptometre, by M. Lissajous. *M. J. Duboscq, Paris.*

716b. Experimental Windchests, for measuring the effect of heat on reeds. *Dr. Stone.*

III.—ANALYSIS AND SYNTHESIS.

717. A series of Chladni's Figures. *Prof. Frederick Guthrie, F.R.S.*

Sand being scattered on a square brass plate, clamped in the middle and horizontal, the plate is bowed at various points of its edge, while various other points are touched with the finger. The sand is accumulated in the lines of least motion or nodal lines. Gummed paper is then pressed upon the figures so formed.

[redacted]

718. Five Wire Figures for representing **Lissajous' Designs.** *Professor Buys-Ballot, Utrecht.*

On a horizontal wooden rod are placed five figures of wire, so bent that their shadows or lens images form the designs of Lissajous. Each interval has its own wire figure, and the changes produced by various phase-differences are shown by turning the figures round their vertical axes.

719. Wooden Board for constructing **Lissajous' Figures.** *Professor Buys-Ballot, Utrecht.*

The instrument consists of a white-painted wooden board, on which a circle is traced. Horizontal and vertical lines cut the circle in points corresponding to the angles of a regular inscribed icosagon. At the intersection of each pair of lines a hole is made in the board for fixing pins; that for showing the figure can be joined by a thread. Along one of the horizontal and vertical sides of the board two rods can be fixed, provided with ciphers corresponding with the horizontal and vertical lines. Each of these lines may be figured to represent the phase of a vibrating particle either by sound or light for each twentieth part of a vertical and horizontal (two rectangular) direction.

For instance, the figure exhibited by the interference of two notes of the same pitch is designed in the following manner:—The horizontal rod indicates the vertical chords on which the particle is at a supposed moment by a horizontal vibration, then the perpendicular rod indicates in the same manner the horizontal on which it would be at the same moment by a vertical vibration. By fixing pins at the intersections of those chords indicated by the same ciphers, and joining them by a thread, you have the desired figure originated by both motions.

If the oscillations differ in phase, you find another rod not beginning with the same cipher, but with another differing as many twentieth parts of the oscillation as you like.

If the two interfering notes are not of the same pitch, but one figure is the octave of the other, you take for the higher note a difference of phase double as great as for the other, and so on.

719a. Tonophant, a simple arrangement for showing **Lissajous' Figures.** *Professor W. F. Barrett.*

720. Melde's Universal Kaleidophon.

Ferdinand Süss, Marburg.

(*See* Poggendorff's Annalen, vol. 114, p. 117.)

This apparatus is too well known already to require in this place a more detailed description as regards its capabilities. It will therefore be necessary to give only a short explanation of the reading indications on the Lamellæ, and to refer, as to all specialities respecting this apparatus, to Prof. Melde's publications. Poggendorff's Annalen, Vol. CXIV., page 117, "Lehre von den Schwingungs-Curven," by Dr. Franz Melde, p. 25.

The great Lamella has on each side a line as a mark, and on its upper end the figures I. and II.; the smaller Lamellæ have the same figures I. and II., and on each side three lines.

If the great Lamella is placed upon the mark of side I., and the small Lamella on the line of side I., with the indication $\frac{1}{4}$, then the vibrations of both Lamellae to each other are as 1 : 4. The indications of side II. naturally correspond to the mark of side II. on the great Lamella.

The Lamella with the little mirror is used when the curves are to be shown to a whole auditory, for which purpose the apparatus ought to be so placed that the rays of the sun, or electric light, fall on the mirror, so that from this the reflection is thrown either on the ceiling or on the wall of the room.

The round bars serve for the production of oscillating curves of two elliptical vibration movements.

Finally, it is to be observed that the apparatus may be used equally well for fixing the vibration curves, for which purpose a phonautograph is employed, the cylinder of which is covered with a paper, *as smooth as possible*, on which soot is laid, but not too thickly.

A small piece of the top of a feather fastened with wax upon one of the smaller Lamellae will be sufficient to describe the curves. In this case, the oscillating surfaces ought to be parallel.

721. Atlas, belonging to the same, illustrative of the theory of oscillating curves, by Dr. F. Melde.

Ferdinand Süss, Marburg.

722. Melde's Tuning-fork Apparatus for producing stationary waves on a thread.

(*See* Poggendorff's Annalen, vol. 109, p. 193; and vol. 111, p. 513.)

Ferdinand Süss, Marburg.

In Poggendorff's Annalen, Vol. CIX, p. 193, and Vol. CXI, p. 513, this apparatus is described more in detail, as well as several experiments which were made with the same, and likewise the theory of the oscillation curves, ("Lehre von den Schwingungscurven") by Dr. Franz Melde, p. 94.

By means of a little sliding rod (a little glass stick) which is screwed into one of the prongs of the fork, and rubbed with wet fingers, the tuning-fork is brought into a state of vibration. (The little glass stick, owing to its fragility, must be inserted reversely into the wooden frame, when not used, so that only the brass-neck of it is visible. On the lower part of the tuning-fork there is a tunable pin, which takes up one end of the thread, and which at the same time serves for stretching the thread. From this point the thread passes through the small neck of the other prong of the fork to the clamp, which can be moved forwards and backwards on the bar, which is about a meter long, and thus allows up to this limit any length of the thread to be fastened. In order to read the length of the thread, there is on one of the narrow sides of the bar a division indicating half centimeters.

The tuning-fork can be turned about its vertical axis in such a way that its oscillation surface falls in a parallel line with the longitudinal direction of the thread, as well as perpendicular to this, or in any other selected angle.

The bar can be turned about a horizontal axis, and arrested in any desired position by means of the nut of a winged screw fixed at the back, so that the thread can form any desired angle with the longitudinal axis of the tuning-fork.

It requires but little practice to effect such a tension of the thread that the required number of waves always appears.

723. Melde's Apparatus for the Combination of Two Thread-vibrations.

(*See* Melde's Lehre von den Schwingungs-curven, p. 99.)

Ferdinand Süss, Marburg.

723a. Melde's Apparatus for the production of **Oscillating Curves** of two **Rectilinear Thread Vibrations** on a **Strained Thread.**

The apparatus consists of two principal parts, one of which is a Lamella, oscillating vertically, fastened on a pedestal, and which is set in oscillating motion by an electro-magnet. The Lamella itself forms the interruptor.

ısists also of a Lamella, which is brought into vibrating ctro-magnet, and the vibration surface of which can be :ed angle to that of the first Lamella.

:he apparatus in motion for experiments both parts must be ı vice pins, either to a long, or on two separate solid tables, at ›out 8–12 feet) from each other that the thread when strained neters in length. (The thread can, of course, be shortened l as be replaced by one a few meters longer; but for college ngth stated appeared to be most practical.) The thread is ı I., and passed through the hole in Lamella II. towards the ıe correct tension is effected.

s on the (red) thread serve for facilitating the better obser- :s, and, in order to render them more prominent, the black ›ehind the oscillating thread. The screen has on one side are hinged in the hooks of the frame of Lamella I.; when ınded, the foot of it is screwed firmly by a vice-pin to the

l) chrome elements, the strength of which may be easily ›est to do service as electro-motors. In the present case :nts were employed, each with two carbon plates, and a n. in height, and 6 cm. in width, joined together one behind

arged, it was only necessary to dip the zinc plate from 1 to acid, in order to obtain the required force of the electric :ments and the wire spirals of both magnets are, of course, current circle. As already observed, Lamella I. serves at ıterference, for which purpose an attachment screw is fixed of the same, which is intended to take up the conduct wire tery. In the attachment screw, which is in connexion with , a wire is fastened, which is to be connected with the first of the wire spirals, if the numbers of the vibrations of the to be in proportion as 1:1 a 1:2 (accord, octave). If perform three or four vibrations in the same time in which only one vibration, then only one wire spindle of Lamella I. y fastening the wire coming from the mercury bowl in the screw. The current must always be so powerful that the e rough displacement is effected by raising and lowering the the more minute displacement by turning the mercury bowl, hat the shutting off of the current is effected as quickly as ›on the purity of the figures chiefly depends.

f the vibrations on Lamella I. is regulated by raising and tro-magnet, which is kept in its position by the nut of a on Lamella II. by screwing in and out the iron coves, and : whole magnet.

ıl current the vibrations will be most regular when the : moved back, and the coves are screwed so closely to the :ontact just ceases.

only one mark on which it always remains accurately ı required that it should oscillate uniformly with Lamella II.

d to the back, marked with the annotation $\frac{1}{1}\frac{a}{-}\frac{1}{2}$ and upon vith × the weight is placed with the annotation $\frac{1}{4}$. If the l further from Lamella II. the oscillations of the two La- : 2. If Lamella II. is moved to the mark indicated by

ions of both Lamellæ are as 1:3 (S fifth of the octave)

...ating the wave undulation. The eight drawings are ...strating the water, rope, sound, and air waves, in covered ...

...Physik," VII. Edit. Vol. I., § 155).

..., on Reis' system, for the reproduction of ...

J. Wilhelm Albert, Frankfort-on-the-Maine.

...based on the experiments of Wertheim and others ...nds. *Philipp Reis*, at Friedrichsdorf, made use of these ...ing by means of galvanic action the musical sounds ... by pipes, &c. played upon), by employing an elastic ...ference apparatus constructed by him.

...des physikalischen Vereins zu Frankfurt a Main. ...o, "Müller's Lehrbuch der Physik, VII. edit. Vol. II., ...

...paratus, for showing the production of pro... waves.

...of. J. Joseph Oppel, Frankfort-on-the-Maine.

...molecules are represented by white wooden balls on ... are all put into motion by a crank attached at the ...

... wave lengths.

Apparatus, for showing directly and com... and stationary waves of sound, and respec... difference between both.

...ssor J. Joseph Oppel, Frankfort-on-the-Maine.

...sponding wave lengths on both cylinders. Other ...r example, with different wave lengths (for illustrating ..., &c.), can be mounted on the cylinders, which are of a ...ape.

Wave Discs of paste-board for stroboscopic ... progressive and a stationary (water) wave.

...ofessor J. Joseph Oppel, Frankfort-on-the-Maine.

...fastened to a rotation apparatus such as are used for ..., and placed in front of a mirror. All waves, with the ...izontal one, should be covered by a black screen.

... Tube, with Gas-burner, for Intonation.

...endorff's Annalen, vol. 129, 1866.)

...Albrecht, Tübingen.

...ing Mirror, movable towards all sides.

...Albrecht, Tübingen.

... not yet been described, but several specimens have already ... Mr. Albrecht. That position of the mirror in which its

normal forms a moderate angle with the rotatory axis, is peculiarly adapted to change the reflected image of the sonorous flame into a beautiful elliptical crown.

731a. Barlow's Logograph, an instrument for recording pneumatic effects of speech, being questions to consonants, as well as records. *W. H. Barlow, F.R.S.*

731b. Apparatus for Synthesis of Vowel Sounds. *Prof. Clifton, F.R.S.*

732. Apparatus for the projection on the screen of the curves produced by the combination of rectangular vibrations. *Yeates & Sons.*

IV.—INTERFERENCE.

733. Apparatus for demonstrating, by the aid of flames, the interference of two musical sounds.

The Director of the Physical Laboratory of the University of Groningen.

The apparatus consists of two curved movable cross tubes, narrowed at one end; their narrow openings, being near each other, are tightly fixed in a longer tube, also ending in a narrow opening; this is placed close to a strong flame, and also a very small flame, which can be seen in a rotating mirror. A little movable burner for this small flame is attached to the apparatus. When a sound-wave proceeds from the opening of the instrument, the strong flame diminishes abruptly in length and begins to roar, while the small flame rapidly vibrates, its motion being visible in the rotating mirror. The open ends of the two curved tubes can be placed before the mouths of two unisonant organ pipes, or above two different segments of a vibrating plate. When only one of the pipes is sounded, the flames show the vibrations, but, when both pipes are sounded, there is no agitation of the flames, the two sound-waves counteracting each other. When the two openings are above segments of the plate, which are in the same phase of vibration, the flame is agitated, but, when they are above segments in the opposite phase, the flame remains at rest.

734. Apparatus, of simple character, for demonstrating by the aid of flames the interference of two musical sounds.

The Director of the Physical Laboratory of the University of Groningen.

This apparatus is designed for the same purpose as that last described, but is of more simple construction.

735. Quincke's Interference Tube, to demonstrate by the action of a flame the diminution and increase of sound by interference.

The Director of the Physical Laboratory of the University of Groningen.

This apparatus is furnished with a supplementary brass tube having a narrow opening. It can be used with the same flames as those provided for the instruments last described.

5a. Interference Apparatus, by Jamin.
M. J. Duboscq, Paris.

5b. Interference Apparatus. *Professor W. F. Barrett.*

BSORPTION, REFLECTION, AND REFRACTION.

3. Apparatus for showing Approach caused by ation. *Frederick Guthrie, F.R.S.*

spended card or mass of cotton wool, or an air ball floating in water, hes a resonant fork; and the latter, when free to move, is also urged s neighbouring matter.

7. Apparatus for showing the Expansion of Gases und. *Frederick Guthrie, F.R.S.*

prong of a tuning fork is enclosed, air-tight, in a glass tube provided capillary exit tube, in which water stands at a certain height. On the free prong of the fork the water level is seen to fall about a quarter ch.

3. Apparatus for the Reflection of Sound by heated l vapours. *Professor Tyndall, F.R.S.*

d of high pitch from a vibrating reed is passed through a long rectan- hamber, and caused to agitate a sensitive flame. Air, saturated with the of a volatile liquid, is gently driven through six narrow openings into amber, at right angles to the direction of the sound. The atmosphere the chamber is thus immediately rendered heterogeneous, and the waves being reflected, the agitated flame is rapidly stilled. The removal heterogeneous medium instantly restores the flame to its former n.

he action of heated air, the rectangular chamber is turned upside pon its support, and the heated air from six gas jets allowed to stream ugh six narrow openings across the sound waves. The air thus d heterogeneous has the effect of immediately rendering the sensitive uiescent.—Phil. Trans., 1874.

9. Diagrams and Apparatus illustrating the reflection fraction of sound-bearing waves, as exhibited to a class by of a sensitive flame. *Prof. W. F. Barrett, Dublin.*

arrangement shows a suitable source of sound, a good form of gas r yielding a tranquil flow of gas to the burner, and the best shape e of steatite burner for the flame, together with a useful form of gas- or giving steady pressure of gas larger than that usually given by the ains.

VI.—RESONATORS.

0. Resonator of adjustable pitch. *Lord Rayleigh.*

nator, whose pitch can be rapidly adjusted to the various notes of a ic scale—A^6, a^6, c^6, a^{16}, c^{11}. The smallest hole is made first and ad- ntil the resonator responds a^6. The second hole is then made and

adjusted, until, *with both holes open*, the note is e^{6}. Similarly with three holes the note is a^{16}, and with four holes c^{11}. When the note A^{6} is sounded on the piano or harmonium, and the resonator is suitably fingered, the various overtones are heard with great distinctness, and the phenomenon is more marked than usual in consequence of the contrast afforded by the rapid transition.

740a. Sonorous Tubes, by Dulong.

Polytechnic School, Paris.

741. Six Resonators of glazed card-board, for the sounds: c' (256 vibrations), e' (320 vibrations), g' (387 vibrations), c'' (512 vibrations), e'' (640 vibrations), g'' (768 vibrations).

Gustav Schubring, Erfurt.

VII.—MUSICAL INSTRUMENTS.

742. Enharmonic Harmonium, with generalised key-board; 84 keys in each octave; compass, 4½ octaves.

R. H. M. Bosanquet.

This instrument is tuned according to the division of the octave into 53 equal intervals, a system sensibly identical with a system of perfect fifths.

References.—Proceedings Royal Soc. XXIII. 390.
Philosophical Magazine, XLVIII. 507, L. 164.
Proceedings of the Musical Association, 1874–5.
Novello's Dictionary of Musical Terms, Article Temperament.
Ellis's Helmholtz, pp. 692–699.

742a. General Thompson's Enharmonic Organ. Built by Messrs. Robson, London, 1856.

John Curwen.

It is an improvement upon a similar instrument he exhibited in Hyde Park, in 1851, which also was an improvement on the first organ built for him in 1834. It is capable of being played in 21 keys, with their minors of the same tonic. The organ is fully described in General Thompson's pamphlet, "The principles and practice of just intonation with a view to the abolition of temperament." Effingham Wilson, Royal Exchange. On the middle finger-board the keys of C, G, D, A, E, B, with their minors, can be played perfectly; on the lowest finger-board there can be played, besides the keys of C and G, those of F, B♭, acute E♭, acute A♭, and D♭. The fingering is mainly the same as in other instruments. The red shows the principal key tone of the board. The black shows the fourth and sixth of that scale, as well as the grave second, with which they make a true chord. The white shows the fifth and seventh of the scale, as well as the acute second of the same scale, with which they accord truly. The small oblong quarrils and the flutals (finger keys of a flute) are always a komma shriller or deeper than the digital in which they are embedded. The buttons are always a diatonic semitone deeper or shriller than the adjacent digital. The serrated edges are for the blind.

742b. Harmonium, with double key-board.

M. Guéroult, Paris.

This instrument, of which the two key-boards are tuned in fifths, has a *comma* at $\frac{81}{80}$ interval one from the other, which serves to verify the theories of musicians and natural philosophers upon the melodic or harmonic gamut.

742c. Harmonium with German silver reeds, for diminishing to the utmost changes of pitch due to alterations of temperature.
Dr. Stone.

743. Patent Double Trumpet, called Bi-Clairon.
Franz Hirschberg, Breslau.

The double trumpet (Bi-Clairon), constructed by the exhibitor, is described by him as an equally interesting and practical invention. As the instrument consists of two bell-mouths of different measure and construction, into which the air can be admitted or from which excluded at pleasure through the solitary valve, it has been rendered possible to produce by the same two kinds of sounds, which, according to their sonorous colour, are now equal to the bugle horn, now to the piston (or, also, to the cornet and the trumpet). The instrument is particularly adapted for being used in concerts, inasmuch as by the different sonorous colours more, " light and shade," consequently more variation, is imparted to the execution, and, therefore, no band of musicians should be without it. In a weak orchestral band, in which both bugle horn and piston (respectively cornet and trumpet) are not always represented, this instrument supplies the place of both. Its pitch is high C with B, and A low, and is so constructed that the smaller bell-mouth can be screwed off, in which case the instrument can be used as a common bugle horn (or cornet).

744. Model of the Action of Grand Pianofortes.
Messrs. Erard.

745. Molineux's Patent Self-acting Escapement and Check Repeater Action for upright Pianofortes. It combines extreme simplicity, a firm and elastic touch, with freedom from friction and great durability. *Thomas Molineux.*

746. The first of the now generally adopted **obliquely strung upright Pianofortes,** patented to Robert Wornum, of the firm of Wilkinson & Wornum, in 1811.
Messrs. Wornum & Sons.

The large factory in Oxford Street, in which this instrument was made, is shown by an engraving within the lid. This factory was burnt down in October 1812, and the partnership was then dissolved. In the following year Robert Wornum made the first successful " Cottage " pianoforte, with *vertical* stringing, to which he gave the name of "The Harmonic Pianoforte." He accomplished this by discarding entirely the use of brass wires, and adopting the closely-spun copper-covered strings in their stead.

747. A Model of the Elastic Tie Action of the Piccolo Pianoforte, patented by Robert Wornum in 1826.
Messrs. Wornum & Sons.

The mechanism of this pianoforte is still very generally adopted in France and Germany, as well as in England.

748. A Model of Robert Wornum's method of returning the hammer, in his **down-striking Action** for Horizontal Grand and Square Pianofortes, patented in 1842.

Messrs. Wornum & Sons.

This action greatly economises the cost of manufacture. The usual actions are upstriking.

749. A Model of Alfred Nicholson Wornum's new **Patent Action** for Grand Pianofortes (1875), in which the heads of the [illegible] are reversed, and now face the wrest plank.

Messrs. Wornum & Sons.

[illegible] longer strings may be used, relatively to the external [illegible] in an instrument of the ordinary construction.

750. Model of the action of **Ancient Great Hydraulic Organ**, from Mr. Chappell's description of the instrument.

Dr. Stone.

751. Marimba or Balafo, from South-eastern Africa. [illegible] by Captain J. Stuart.

South Kensington Museum.

[illegible] wood, beneath which are [illegible] gourds, to increase the [illegible] is at the top, and the [illegible] delicate film, to promote [illegible] have noticed this curious [illegible] of the skin of a [illegible] to instruments of [illegible] Africa. The marimba is [illegible] Kafirs.

[illegible] Made by E. Pohl, in [illegible]

[illegible] Kensington Museum.

[illegible] which are affixed in [illegible] and which by [illegible] produced by [illegible] the bells while [illegible]

[illegible] Glover. In- [illegible] the theory of [illegible]

[illegible] Kensington Museum.

[illegible] of their manu- [illegible]

H. Speechly.

[illegible] constructed key- [illegible] The common [illegible] with the [illegible]

[illegible] Read.

iromatic Pianoforte, peculiarly constructed key- which the keys are distinguished by different colours. facilitate the playing in the different major and minor

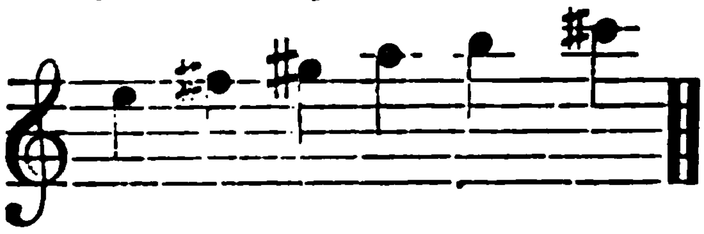
Mrs. Read.

odels of several **Ancient Egyptian Pipes,** the which are in the Egyptian Museum at Turin or in the seum. Those from Turin are copied in brass, and the British Museum in cane.

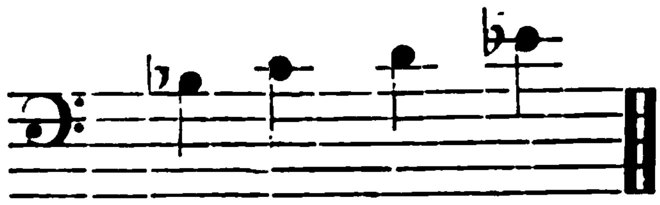
W. Chappell, F.S.A.

il pipes were found in Egyptian tombs, some examples being as urth or fifth dynasty of Egypt. They were played upon by t or split piece of reed or of straw inserted in the end, as was cient shepherds' pipes, and much in the manner of the modern gpipe reeds. Parts of the ancient reed or straw remain within es in the British Museum, and in another at Turin. Usually a ce of reed or straw was laid in the tomb by the side of the pipe, : assumed that the object was to supply the dead man with a perishable inciters of tone in order to play upon his pipe when camples of the straws or reeds so deposited are included in the :yden and in the British Museum.

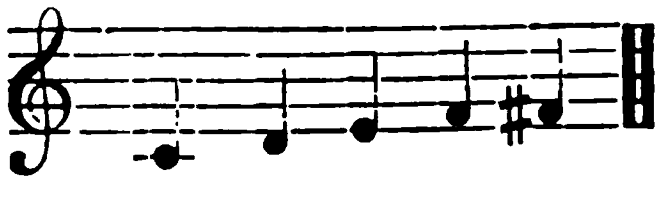
:lected for copying were those which varied in length and in the ger holes, so as to obtain varieties of pitch, and varieties of the les. Through the kind assistance of Dr. W. H. Stone, himself ied player upon reed instruments, the following have been

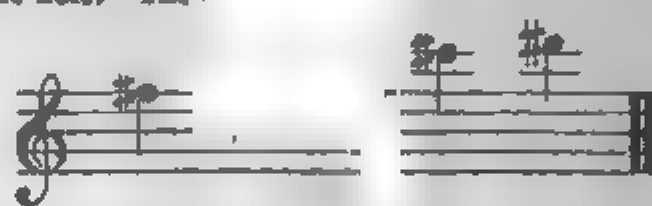
m Turin $14\frac{1}{8}$ inches long, with six finger holes. Scale—

le of E major, but only extending to six notes. It lacks the ♯ and E to complete the octave. The fundamental note, or tone ipe, was not obtained.

:est pipe from Turin, $23\frac{3}{8}$ inches, but with only three holes.



Diatessarōn, or Fourth from B-flat to E-flat, therefore one note) E F in pitch. In order to obtain the notes from this pipe, it :essary to lower the reed into the pipe, as in the drone of a xtends three inches down the tube.

ı the British Museum, copied in cane. It has four holes, and is ngth. The scale is a Diatessarōn or Fourth, exactly one note , but with an F sharp added to it at the top. Possibly this ıave been intended for a G to make a Fifth.

the British Museum, copied in cane. It has four holes, length is 10½ inches. This pipe has a hole bored through it end. It would have been absolutely impossible to produce pipe if this hole had been left open. It may therefore be that it was once covered with thin bladder, such as that of a fish. The intention of placing bladder there would have been to give a tremulousness to the tone of the pipes so as to assimilate it to the human voice. The old English pipe called the Recorder, referred to by Shakespeare in Hamlet, and in A Midsummer Night's Dream, differed in no other respect than that one from the English flute, both being blown at the end. It is curious to find that such an appreciation of the ce of tone that might be produced has been anticipated by the ians. A film of gutta percha is now tied over the hole. The



This is a peculiar scale, a pentatonic major scale, such as is popularly entitled the Scotch scale. It is su playing tunes as upon the black keys of the pianoforte.

It is remarkable that no one of these pipes gives any indication of a minor key, and they seem therefore to be older than the introduction of the minor scale, inherited by us from the Greeks, by the junction of two tetrachords. For this an astronomical or theological reason is assigned, that, as there were but seven planets (according to ancient supposition), and seven days in the week, or quarter of the lunar month, &c., so there should be but seven notes in a musical octave. Therefore a scale of two tetrachords, each of four notes, was reduced to seven, through uniting them by one note common to both. Hence the intervals of our B C D E F G A.

757a. Indian Vina, with resonating gourds.
W. Chappell, Esq.

757b. Patent Comma Trumpet, producing approximately correct intonation, by means of a valve, which raises the pitch the interval of a comma. *Mr. Bassett.*

757c. Marimba from **Angola,** on the principle of the musical box. *Mr. Bassett.*

757d. Wooden Trumpet from **Angola,** made from the root of a tree. *Mr. Bassett.*

757e. Violin, fitted with tension bars. *Dr. Stone.*

757f. Double Bass, with heavily covered fourth string, going down to C C C. *Dr. Stone.*

759. Savart Violin.
Conservatoire des Arts et Métiers

759a. A new Orchestral Musical Bass Instrume concertina fingering, full tone, and expressive for part performance. *Sir F.*

758b. Acoustical Instrument, illustrating Harmony d Discord. *Sir F. Pichler.*

759c. Violin fitted with Tension Bars. *Dr. Stone.*

759d. Viol d'amore, illustrating the principle of consonating ings. *Dr. Stone.*

VIII.—SPECIAL COLLECTIONS.

Detailed List of Instruments manufactured by M. Lancelot of Paris.

Exhibited by Auguste Bel & Co., London.

760. **Eight Pieces of Wood,** giving a scale.

761. **Mouth of a Flute Pipe,** showing the inside of the chamber.

762. **Wertheim's Apparatus.**

763. **Pipe** with glass side, and membrane.

764. **Pipe** carrying a slide, enabling holes of different sizes l shapes to be opened in the same situation.

765. **Four Pipes,** all containing the same mass of air, one ndrical, one cubical, one tetrahedral, one spherical.

766. **Three Pipes** containing the same mass of air, one prisic, one in the shape of a right cone, one in that of an inverted e.

767. **Mons. Bourbouze's Pipe** with glass side, bearing e membranes, with mirror, one placed at the node of the first nd, the two others at the two nodes of the second sound.

768. **Six Plates,** five of different woods, one of brass.

769. **Two Flat Rods** of brass for transverse vibrations. pport for fixing these.

770. **Sonometer** on Mons. Barbereau's principle.

771. **Circular Membranes,** with varied tensions.

772. **Two Tuning Forks** on resonance box, to give four ts a second.

773. **Two Tuning Forks,** mounted between the poles of tromagnets, with contact-breaker.

774. **Duhamel's Vibroscope.**

775. Apparatus for transmission of vibrations through liquids.

776. Instrument for showing the quality of vowel-sounds.

Various Scientific Instruments illustrating the Phenomena of Sound, invented and made by the late John Henry Griesbach.

777. A Monochord, with ... ratus for printing and registering the vibrations of strin... a view to ascertaining the number of vibrations per sec...

778. A Phonometer, by ... of which the equally tempered 12 fixed sounds in the octave m... produced.

779. A Monochord, giv... positions of the Nodal Points in vibrating strings.

780. A Monochord, which affords the means of measuring the 200th part of an inch, with a view to ascertaining the number of vibrations given by that length of string.

781. An Apparatus for producing musical sounds, mainly consisting of notched wheels of different diameters, which, being set in motion at a given pace, and duly prepared pieces of cardboard brought in contact with their teeth, produce the notes of the common chord; the number of notches in the wheels corresponding with that of the vibrations required to produce those notes.

782. An Apparatus for showing the relative positions of the vibrations of two strings or tubes under the operation of altering the ratios; the strings first tuned to coincidence as unisons, the ratios then altered by lowering the pitch of one of the strings, as from 81 to 80, 82 to 80, or any other numbers within the scale of the apparatus.

783. A Set of Flue Pipes, with bellows attached, some of which have too high sounds to be heard singly, but which together give the resultant tone.

784. A large Set of Coloured Diagrams for illustrating lectures on sound.

---

785. Collection of Acoustic Apparatus.

George Appunn and Sons, Han

785a. Three Acoustic Wind-Chest Tables. These three tables are required for placing all the following apparatus :—

George Appunn and Sons.

1. *An Overtone Apparatus*, consisting of 24 lingual tones, the first 64 part tones of the fundamental or key tone (primary sound) $C^{-2} = 22$ vibrations in a second with reed pipes.

2. *The same Apparatus*, consisting of 32 lingual tones, the 32 part tones of the fundamental tone $C^{-2} = 32$ vibrations.

On the overtone apparatus there result quite plainly the corresponding difference-tones of all phases that may be chosen at pleasure; also, up to a certain point, the corresponding resultant tones. By means of this overtone apparatus not only the waves and the quality of the sound can be demonstrated, but likewise the different degrees of harmony of the various musical proportions (rhythm), and of poly-accords in different keys and transpositions. The latter, in particular, in combination with the *tone limit apparatus* for low tones, mentioned hereafter.

3. *A Tonometer*, consisting of 65 lingual tones; every subsequent tone by 4 vibrations (waves) higher than the previous one, from $\tilde{c} = 256$ to $\bar{\bar{c}} = 512$ vibrations in a second; with reed pipes.

4. *Tonometer*, consisting of 33 tones; each succeeding tone being 4 vibrations higher than the preceding one, from $c = 128$ to $\bar{c} = 256$ vibrations in the second.

(*Note.* By the number of vibrations given, double vibrations (waves) are always to be understood.)

5. *Tone-limit Apparatus*, for low (pitch) tones; consisting of 57 lingual tones, with reed pipes, from $c = 128$ vibrations downwards to 8 vibrations in a second, namely, from $c^{o} = 128$ to $C^{-1} = 64$, every subsequent tone in the descending scale by 4 vibrations lower than the next preceding tones from $C^{-1} = 64$ to $C^{-2} = 32$, each two vibrations lower, and, lastly, from $C^{-2} = 32$ vibrations downwards, each one vibration lower as far as 8 vibrations.

6. *Tone-limit Apparatus*, for high (pitch) tones; consisting of 31 small tuning-forks, the diatonic Durton scale c; d; e; f; g; a; h; c; 24 : 27 : 30 : 32 : 36 : 40 : 45 : 48. through 4½ octaves, namely, from $c^{iv} = 2048$ vibrations (double) to $c^{viii} = 40{,}960$ double vibrations, with two bows (fiddle-sticks).

In order to be able to observe, and to perceive better and more distinctly with the tone-limit apparatus for high tones (tuning-fork apparatus of 31 tuning forks), the ascending scale up to the highest pitch, it will be advisable to intonate with two bows (fiddle-sticks) the scales in octaves the one after the other, and thus to sound every tone with its octave simultaneously or one directly after the other.

7. *Two large Gedact Pipes* (stopped mouth pipes), whose pitch can be lowered an octave, with small wind chest and wind trunk, for illustrating the interference, waves, resultant tones, &c.

8. *Two smaller Gedact Pipes*, with small wind chest and wind trunk, for the same purpose.

Very powerful-sounding *Lingual* (*reed*) *Pipe*, accompanied by a large number of overtones, with bell-mouth : $C^{-2} = 32$ vibrations in a second.

Twenty-nine Resonators to the same, from the 4th to the 32nd overtone. (The resonators are conical, and made of zinc.)

Reed pipe, with bell-mouth, $C^{-1} = 64$ vibrations.

e. Four open and four stopped *Labial Pipes*, with small wind chest and valves, producing the C major accord : $\overline{c} : \overline{e} : \overline{g} : \overline{c}$.
$8 : 10 : 12 : 16$

f. Accord Reed Pipe, producing the C major accord $c : e : g : \overline{c} : \overline{e} : \overline{g} : \overline{c}$.
(The two apparatus *e* and *f* are for demonstrating the quality of sound.)

786. A Stand of Apparatus illustrating the progress of Æolian Principles.

J. Baillie Hamilton.

1. Primitive Æolian types.
   The rod.
   The bow.
   The harp.
2. Modern Æolian harp.
3. Wind concentrated upon a [illegible]ng, and applied to its entire length. By Professor Robins[illegible]
4. Wind applied to a porti[illegible] the string, as by Wheatstone, Green, Isoard, &c.
5. Further modifications of the same.
6. Use of a free-reed. By Pape. The connexion with the string being effected by a silk thread.
7. Julian's mode. A metal string flattened into a tongue at the part where the wind impinges.
8. Farmer's mode. A reed-tongue substituted for the flattened portion.
9. Farmer and Hamilton's mode. A rigid connexion between reed-tongue and string allows the reed to be used as in reed-organs.

SUBSEQUENT INVESTIGATIONS BY HAMILTON IN CONJUNCTION WITH HERMANN SMITH.

10. Improved string-organ note, in which a sympathetic resistance is offered to the string, the vibration transmitted to the soundboard, and constancy of pitch preserved by a spring-bow. The reed tone is modified by a tube, and the connexion effected through the tube by a "purse," the latter suggested by Hermann Smith.
11. Further modification by Hamilton. The necessity for the "purse" abolished by setting both reed and string inside the register. The economy of space effected by Hamilton's spiral spring, and the use of a short metal spring-bow.
12. Application of these improvements for use in a wind-viol. Also a conical string, invented by Hamilton, for obviating the following difficulties peculiar to reeds and strings in combination.
   a. The difficulty caused by the string breaking into segmen[ts] owing to the constraint on the reed, and the scarcity [of] notes obtainable.

b. By the irregularity of intervals which, in a cylindrical string, are crowded together near the reed, and are far apart when remote from it.

c. By the irregularity of tone in different portions of the string's length. When an ordinary string is used in short lengths the reed's motion is confined, and the tone is consequently pure; as the string lengthens, the tone becomes loose and coarse.

d. By the reducing of the string's bulk by stretching when tuned, as the reed remains constant the intervals would be changed when the string is thus attenuated.

The conical string meets these difficulties thus,—

a. The bulk of the string lies in the part used for playing upon, and thus no intervals are wasted.

b. The bulk is increased where the intervals would otherwise be wider.

c. The increasing bulk controls the reed equally at all points.

d. If tuned from the smaller end the string does not become attenuated, as more bulk is brought over the other bridge.

13. Apparatus for studying the relative amount of tone contributed through the string.

a. By the action of a soundboard and bridge.

b. By the reciprocal action of a spring-bow.

The spring-bow can also be rendered rigid, and the tone is then due merely to the constraining effect of the string on the reed's motion.

14. Æolian effects produced by percussion. For investigating the causes of the Æolian tone.

15. Apparatus investigating the most effective modes of—

a. Constraint upon a reed.

b. Transmission to a soundboard.

An intermediate mass is here used for transmission.

16. Apparatus showing how far quality of tone can be now affected by reaction from the soundboard. By placing a weight on different parts of the soundboard any quality of tone can be produced.

17. Further modifications for reducing these principles to practical use by altering the relation of levers and spring resistance, and substituting for the intermediate mass the structure of the register, which, as in No. 18, is itself the conductor to the soundboard.

18. Register embodying the foregoing improvements into a form for practical use, and illustrating the different forms of constraint applicable to reeds.

19. A new form of vibrator applicable to all solid bodies as

well as to columns of air. Invented by James Baillie Hamilton, April 1876.

20, 21, 22. Apparatus for studying the laws of strings combined with reeds.

IX.—EDUCATIONAL.

787. Apparatus for illustrating lectures. *Auguste Bel & Co.*

788. Graphical Representations of Musical Scales, on paste-board. *Gustav Schubring, Erfurt.*

The logarithms of the numbers of [illegible]rations and their differences were first recognised by *Euler* (Leonhard [illegible] tentamen novae theoriae musicae, 1739). These logarithms were a[illegible]riod used by *Opelt* (" Natur der " Musik," 1834, " Theorie der M[illegible]r the graphical representation of musical scales. *Herbart*, likewis[illegible]ployed them in his psychological speculations, and, lastly, *Prof. L.* [illegible] (Leipsic) has extensively applied them in his calculations of the mus[illegible]tervals (Abhandlungen der fürstlich Jablonowskischen Gesellschaft, 18[illegible]).

The exhibited plates are especially intended to illustrate the musical scale calculations of Prof. Helmholtz; they agree in their annotations with those employed in the older edition of the "Lehre von der Tonempfindungen" (Part III, sections 15 and 16). A reconstruction of these plates, according to the annotations used in the new edition, is in course of execution.

789. Model for the Higher Tones. *Gustav Schubring, Erfurt.*

Prof. Mach (Prague) has made use of the high-tone scales, drawn according to logarithmical scales, in order to produce a model for the high-scale tones. By means of the same not only can the higher tones of any sound be ascertained directly, but the higher tones of several sounds can also be compared the one with the other. Altogether the theory of the musical consonance and dissonance advanced by Prof. Helmholtz can be demonstrated thereby in the most excellent manner.

Prof. Mach's model had a length of three octaves, and contained the high tones according to the tempered free-balancing scale.

The model exhibited is more than four octaves long, and contains the high tones in the pure (natural) key.

789a. Model, similar to the two preceding, but not on paste-board. *Gustav Schubring, Erfurt.*

790. Sir Charles Wheatstone's Mechanical Illustration of the Vibration of Strings or Rods. *W. Groves.*

SECTION 7.—LIGHT.

West Gallery, Upper Floor, Room Q.

DETERMINATION—VELOCITY.

791. Original Apparatus, by M. Fizeau, for measuring the velocity of light. *Polytechnic School, Paris.*

792. Apparatus, by M. Foucault, for measuring the velocity of light. *Polytechnic School, Paris.*

I.—DISTRIBUTORS.

a. Lenses.

795. The Phakometer (Snellen), for the determination of the power of lenses (by the method of placing object and image at equal distances from the lens). *Dr. Snellen, Utrecht.*

The object (points of light on ground glass) and the screen upon which the image is received are moved in a perfectly similar manner, but in opposite directions, each by an enclosed steel spring.

For the determination of weak lenses, an auxiliary lens, No. 2·75, is placed on each side of the lens examined (at a distance of 0·025 from the centre).

The screen which receives the image moves alongside a scale, upon which at each double focal distance of the system of the three lenses (obtained by calculation) is marked the power of the lenses used in ophthalmological practice. Within $\frac{1}{20}$ "dioptric" one can with sufficient accuracy estimate how much the lens examined differs from the powers marked on the scale.

The image having constantly the same magnitude, precise adjustment is easy. The screen possesses a diagram of the image. The image of the points of light covering this diagram, the centre of the glass coincides with the diameter of the instrument. Not only the focus, but also the centre can be determined directly.

The scale may be controlled at any time by determining the strong glasses directly, the auxiliary lenses being removed. Then the double-focal distance is to be taken from the corresponding principal plane to the point where the image is formed.

The instrument as yet is only adapted for symmetrical (biconvex) lenses. In order to determine plano-convex or periscopic glasses, it will be best to place two glasses of equal power one against the other, so as to obtain a symmetrical form. According to the calculated principal planes of this system, a scale may be computed.

..a Iceland Spar Ball. *A. Hilger.*

..ens, by Stocker, modified by Dr. Snellen. The ..licated above has been utilized with two cylindrical 12°=12°). When the cylindrical surfaces are parallel, ..ction becomes annulled ; when they are crossed, they ..led. The axis is fixed for the same reasons as above.

M. Crétès, Paris.

..eries of Metrical Glasses. The dioptric unit of one metre focus ; the lens 0·50 to two metres .. semi-dioptric value of the unit ; the lens 2 to 0·50 .. dioptric value of double the unit. The same rule ..ll the other lenses in the collection. *M. Crétès, Paris.*

..lobe made of Spar. *M. Lutz, Paris.*

..arly form of Stereoscope.

..eatstone Collection of Physical Apparatus, King's ..ollege, London.

..arly form of Stereoscope.

..eatstone Collection of Physical Apparatus, King's ..ollege, London.

..he Polistereoscope.—Apparatus which serves as ..pe, pseudoscope, iconoscope, &c., &c.

..ustus Righi, Professor of Natural Philosophy, Royal ..chnical Institute, Bologna (Italy).

..us consists of two plane mirrors, one of which (on the left in ..an turn about an horizontal and a vertical axis ; the other .. these movements, can be fixed at different distances from the ..eyes must be applied at two cylindrical tubes fixed to a dia- ..can take different positions. One of the eyes sees directly the ..he other sees the same object but apparently in a different position. ..sition can be determined by forming the image of the eye, given ..ror, and after the image of the point so determined in relation ..rror. If objects not too near are observed the illusion succeeds .. the image in the eye which sees by reflection is smaller than ..cording to the inclination which is given to the mirrors, it is .. any determinate point of the observed objects appear in the

..e apparatus be placed as in Figure 1, it produces the effect of ..pe.

..ed as in Figure 2, it acts as a pseudoscope. According to the ..n the mirror, diminution or augmentation of relief can be .. inversion of relief. Some curious effects (which cannot be ..a Wheatstone's pseudoscope) are observed by looking at ..rical solids, constructed with metallic wire, or by looking at ..le the observer moves round them.

..n the apparatus placed as in Figure 3, the effects of an icono- ..ned. A very narrow mirror is substituted.

..ig. 4 the apparatus is placed so that the eyes see the objects as ..a same plane perpendicular to the right line which joins the

[redacted]

eyes; the relief in objects made with vertical wires then disappears. If the diaphragm which bears the two tubes is kept fixed, and the instrument turned slowly round the left tube, very curious apparent motions occur in the objects under observation.

For the mathematical theory of this apparatus, *see* the "Nuovo Cimento," 2[d] ser. t. xiv.

813. Jewel Lens (Ruby) of $\frac{1}{80}$ inch focus. Made by Mr. Andrew Pritchard, at the suggestion of Sir David Brewster. (*See* Brewster's "Optics," 1831, p. 337.) *John Spiller, F.C.S.*

813a. Vertical Apparatus for Projections.
M. J. Duboscq, Paris.

813b. Projecting Apparatus, for all phenomena of double refraction and polarization. *M. J. Duboscq, Paris.*

813c. Support, with Reflector, by Fresnel.
M. J. Duboscq, Paris.

b. Lanterns, Cameras, &c.

814. Oxy-hydrogen Lantern, of new form, suitable for lecturers. *C. J. Woodward.*

The lantern is mounted on a "Willis's stool," so that supports of various kinds may readily be attached. The body of the lantern is swung between two uprights, and can be clamped so as to send a beam of light at any angle; this, combined with a rotatory motion in a horizontal plane, enables the lecturer to direct a beam in any required direction. A rod carries lenses and a mirror when it is required to throw the light vertically upwards on an object, as, *e.g.*, for cohesion figures.

816. Camera Obscura. An early example, said to have belonged to Sir Joshua Reynolds. *South Kensington Museum.*

This camera when closed has the form of a large folio leather-bound book. It is recorded to have been given by Sir Joshua Reynolds to Lady Yates, by whose great grand-daughter, Mrs. J. R. Harrison, it was, in May 1875, presented to the Museum.

816a. Camera, by Colonel Laussedat. *M. Lutz, Paris.*

816d. Camera Lucida, invented and used by Dr. Wollaston.
G. H. Wollaston, Clifton.

816g. Camera Lucida, with slight magnifying power.
A. Nachet, Paris.

816h. Camera for Landscapes, by M. Gori.
A. Nachet, Paris.

816i. Camera Lucida, invented and used by Dr. W. H. Wollaston. *G. H. Wollaston.*

817. Improved Electric Lamp and Lantern for Lecturer's use. *John Browning.*

The lamp is automatic, the carbon poles being drawn asunder in proportion to the strength of the battery power used; this is effected by drawing iron rods into a hollow coil of insulated copper wire. The lantern has two nozzles, one intended for exhibiting screen experiments in spectrum analysis, polarisation, refraction, reflection, diffraction, &c. The second nozzle is for exhibiting diagrams on the same screen, without altering the arrangement of the apparatus for physical experiments.

818. Lithographs for the Stereoscope, from drawings by J. Müller, Hessemer, Oppel, Nell.

J. Wilhelm Albert, Frankfort-on-Maine.

The coloured drawing marked with A (upon grey cardboard) is the original made by the late Prof. *Müller*. Images 2, 3, and 4 serve for a stereoscope without glass. The other images refer to stereometrical, astronomical, and optical (colour combinations) subjects. Some images appear, by a slight change of position, in low or high relief.

819. Edelmann's Spectral Lamp, for the projection of the spectra. *M. Ph. Edelmann, Munich.*

820. Printed Treatise to the same.

M. Ph. Edelmann, Munich.

821. Duboscq's Lantern. To be used in connexion with the following apparatus:—

1. Top with illuminating lens; is to be employed with spectral slit and polariscope.
2. Spectral slit; can be regulated by means of a fine screw.
3. Stand with convex lens; serves for the projection of the rays in spectrum experiments.
4. Two hollow prisms.
5. A prism plate for two prisms, arranged for being turned and put higher or lower.
6. Stand with holder for a prism; can be regulated.
7. Polariscope.
8. Lens system, with four-inch illuminating lenses and achromatic objective; serves for the projection of photographic and other glass images of about 3 inches in diameter.
9. Microscope. This can be screwed to the end of the preceding system of lenses, after the objective has been removed.
10. Regulator for producing electric light; can be regulated.
11. Hydro-oxygen gas lamp.
12. Apparatus for hydro-oxygen illumination, arranged for the jection of opaque objects.

A. Krüss, Hamburg.

21a. Photogenic Lantern. *M. J. Duboscq, Paris.*

'2. Double demonstrating Oxy-hydrogen Lantern, triple condensers, consisting of two 10-inch plano-convex

In practice, however, it is found necessary to vary the striking distance with the composition, and the amount of this variation is still under investigation.

826. Spectroscope for determining the smallest displacement of spectral lines, and for measuring velocity of motion.
Professor Carl Wenzel Zenger, Prague.

This new instrument gives double images, two spectra produced by an additional prism of quartz or calcspar, giving two dark lines in parallel directions, *e.g.*, the D. line, and of constant distance, if there be no motion towards or from the luminous body. The motion of heavenly bodies producing, therefore, the displacement of both D lines, and an accurate micrometer measuring it, gives the amount of velocity.

827. Hermann's Taomatoscope, for examination and demonstration of absorption bands in fluids by the spectroscope.
Professor Dr. L. Hermann, Zürich.

The fluid is poured into the little chamber, and the thickness of the layer is regulated by sliding the inner tube until the bands appear.

828. The Collection of Prisms of crown and flint glass used in the construction of refractors and spectroscopes by Steinheil and Merr at Munich, and by Hofmann at Paris, whose refractive indices for 50 lines in the solar spectrum were determined by Prof. Van de Willigen. *Foundation Teyler at Haarlem.*

Steinheil No. I. flint, No. II. flint, No. III. crown glass.

Merr No. I. and No. II. both of the same heaviest flint, No. III. crown, No. IV. crown, No. V. and No. V*a*. both of the same ordinary flint glass.

Hofmann No. I. heavy flint glass.

See " Archives du Musée Teyler, " Vol. I. p. 31, 64 and 205, and Vol. II. p. 183.

See the chemical composition of crown Steinheil No. III., and Merr No. IV., and of flint : Steinheil No. II., Merr No. I. and No. II., and No. V. and No. V*a*., and Hofmann No. I., given by Prof. P. J. van Kerckhoff, " Archives du Musée Teyler," Vol. III. p. 117.

Steinheil No. II. and No. III., Merr No. I. and No. II., No. IV. and No. V. and No. V*a*., and Hofmann No. I. are accompanied by parallelopipeds and plates of the same glass and by pieces or powder for chemical analysis.

829. Powerful Spectroscope, with Browning's automatic action, for adjusting the prisms to the minimum angle of deviation of the ray under examination. *John Browning.*

In this instrument the ray can be made to pass four times through the six prisms, and a dispersive power of 24 prisms thus obtained can be used, or that of any lesser number of prisms at pleasure. The instrument is fitted with a new reflecting bright line micrometer; when measuring with this contrivance no light is visible in the field of view, but the wires of the micrometer are seen faintly illuminated.

830. Universal Spectroscope, with Browning's automatic action, giving a dispersive power of from 2 to 12 prisms.
John Browning.

831. Spectrometer, straight sighted, with apparatus for registering observations.

Geneva Association for Constructing Scientific Instruments.

This straight-sighted spectrometer is distinguished from others of the same description, in that the distance of the rays of the spectrum is measured, not by the superposition of the spectrum sighted upon a lighted micrometric scale, but by measuring the angle formed by the eye-piece for marking the reticle of the telescope from one line upon the other, and then comparing with the angle formed by the telescope pointed on two lines of known distance. A tangent screw effects the angular displacement of the telescope; this screw bears a calculatór which serves to read angular displacements of less than 20 seconds. A recorder, formed of a movable pencil which acts upon a; counter, serves to make series of observations in the dark. The telescope of the line of collimation which bears the slit, possesses also an angular motion which serves to bring any portion whatever of the spectrum in the centre of the compass of the eye-piece.

832. General Apparatus for Spectroscopy, Polarisation, Reflexion, Refraction, and for various experiments in **Fluorescence.**

Geneva Association for Constructing Scientific Instruments.

This apparatus has been constructed with the object of carrying out, with one and the same instrument, all, or nearly all, experiments in spectroscopy, rotatory polarisation, reflection, and refraction. The divided circle is movable around an axis, and serves to bring the rays of light at any angle upon the eye-piece of the line of collimation. For experiments in spectroscopy, a table of one, three, or six prisms may be set up. The prisms are raised above the divided circle sufficiently to allow of their being heated from below if required. For determination of the line of collimation suitable arrangements have been provided, and for experiments in polarisation, eye-pieces fitted with divided circles and nicols; a Babinet compensator may also be adapted to them. The first apparatus of this kind was constructed for the use of Professor Wiedemann, of the University of Leipzig.

833. Large Spectrometer, according to Meyerstein's system, for determining the relations of refraction and dispersion of different media, with contrivance for polarisation.

Schmidt and Haensch, Berlin.

834. Smaller Spectrometer, of the exhibitors' own construction. *Schmidt and Haensch, Berlin.*

835. Spectrometer, according to Abbé's system, with divid circle of 20 cm. diameter, repetition circle, and micrometer aratus for determining the dispersion. Additional to the same, ollow prism with metal body. *Carl Zeiss, Jena.*

e spectrometer has only *one* telescope, which serves at the same time ollimator and as instrument of observation. The adjustment brings t automatically the minimum of deviation for every ray. The measure- of the refracting angle and that of the deviation takes place without

ng the refraction and the refracting angle; the small tubes are for the isation. Determination of refraction and of refracting angles are ed as with the larger instrument, except that the telescope is put into lace of the micrometric tube. Solid bodies, when submitted to polarisa- are fixed with some wax against the plate which is put up in the black When liquids are to be investigated, the small circle with its clamps is ly removed, the screw, which maintains the principal circle in horizontal on, taken out, and the instrument turned down until the main circle s quite vertically, when it is fixed again by the screw. For all polarisa- experiments *Babinet* compensator is fixed by means of the two screws the bearer of the telescope.

39. **A hollow Prism,** according to Dr. Meyerstein, which ed for optical analysis with the spectrometer.

Aug. Becker (Dr. Meyerstein's Astronomical and Physical Workshops), Göttingen.

40. **Rigid Spectroscope** by Browning, constructed for Gassiot on the design of Dr. Balfour Stewart, with the view termining whether the position of the D lines of the spectrum nstant, whilst the co-efficient of terrestrial gravity is made to

Kew Committee of the Royal Society, Kew Observatory.

s described in the Proceedings of the Royal Society, Vol. XIV., p. 320. servations were made by it from 1866–1869, on board H.M.S. "Nassau," g a voyage to and from the South Pacific, and subsequently at the Kew rvatory until 1872, the results of which are not yet published. consists of a train of three prisms, the last of which is silvered on one so as to return the light which falls upon it. Close to the slit another n is placed, which reflects the rays on their way back into a micrometer, hich the position of the D lines is measured."

41. **Vierordt Spectroscope,** adapted for the measure- t of absorption spectra and for quantitative chemical analysis.

Franz Schmidt and Haensch, Berlin.

is apparatus is described in Vierordt's work on the "Application of the ectroscope to the Photometry of Absorption Spectra, and in Quantitative emical Analysis." Tübingen, 1873.

42. **Browning Spectroscope,** applicable to the exami- ion of absorption spectra, according to Vogel's method.

Franz Schmidt and Haensch, Berlin.

43. **Mitscherlich's Stand** for use in the spectroscopic mination of coloured flames.

Professor A. Mitscherlich, Münden.

44. **Pocket Spectroscope,** showing sodium line in a le burning candle, of great use in chemical and meteorological rvations. *A. Hilger, London.*

45. **Hilger's Pocket Spectroscope,** showing all the prin- Fraunhofer lines, dividing D easily with nickel line between; n on sun, a sliding slit with division adjustable to position. les a limb in front of eye-piece. *A. Hilger, London.*

846. Pocket Spectroscope of the simplest and cheapest kind. *A. Hilger, London.*

847. Two perfect Right-angle Prisms. *A. Hilger.*

848. Nicol and a Double Image Prism. *A. Hilger.*

849. Spectroscope made by Yeates, of Dublin, fitted with a diaphragm instead of cross threads for measurement of position of lines. *Professor Jos. P. O'Reilly.*

The diaphragm, above, being perfectly opaque, is always visible against even the faintest lines; moreover, it dispenses with the introduction of an extraneous light which may by its brilliancy interfere with that of faint lines. This spectroscope is specially adapted for the examination of fluorescent minerals, the prisms and lenses being of quartz.

850. Spectroscope, with bi-sulphide of carbon prisms and lens, arranged for projection. *Yeates & Sons.*

The prisms and collimating lens are so proportioned that no light is lost by passing outside the prisms or otherwise.

851. Spectroscope, with compound prism and angular scale. *Yeates & Sons.*

852. Spectroscope, with two prisms. *James How & Co.*

853. Three Foucault's Prisms.

Fluor-spar, cut in three directions.
Small rhombohedron of fluor-spar.
Cone and pyramid (black) for Guérard's apparatus.
Cone for the projection of annular spectrum.
Pyramid for the projection of four spectra.
M. Mascart's prism.
Small prism of crown glass.
Two polyprisms (glass).
One polyprism (quartz).
Collection of nine prisms.
Boscowich prisms.
Fresnel's tri-prism.

Laurent (Paris).

854. Prisms for direct Vision in 3 pieces.
„ „ „ 5 „
„ „ „ 7 „
Rochon prism.
Wollaston prism.
„ „ (small).
Fluor-spar prism.
Cube of fluor-spar.
Fluor-spar lens.
Three cells for spectroscopic work.
A collection of quartz and fluor-spar prisms.
Spectroscope with one prism.
Object-glass for projecting ray spectra.

Laurent.

854a. Collection of Prisms, for optical purposes.
Laurent, Paris.

854b. Spectroscope. *M. J. Duboscq, Paris.*

854c. Prisms, by Arago. *Paris Observatory.*

854d. Prisms, by Borda. *Paris Observatory.*

854e. Collection of Compounds of Silicon with various **Metals** for optical purposes. *Feil, Paris.*

1. Disc of Crown Glass, 4 inches.
2. Disc of Flint Glass, 4 inches.
3. Plate of Crown Glass (heavy English).
4. Parallelopiped, of ordinary flint glass.
5. Crown Glass Prism.
6. Flint Glass Prism.
7. Flint Glass Prism, (sp. gravity 4·4.)

7a. Prism manufactured by Fraunhaufer Guinand.

8. Flint Glass Prism (very heavy), sp. gr. 4·4.
9. Flint Glass Prism, sp. gravity 4.
10. Flint Glass Prism, sp. gravity 5·2.
11. Flint Glass Prism, sp. gravity 5·5; samples by the dry method.

11a. Silicate of Potassium and Calcium with Titanium.

12. Aluminate of Silicium and Magnetism.
13. Crystallisation of Alumina and Magnesia.
14. Crystallisation of Fluosilicate of Magnesium and Calcium.
15. Alumina and Magnesia Crystallised by Fluosilicate of Potassium.
16. Crystallisation of Fluosilicate of Aluminium.
17. Crystallisation of Barosilicate of Aluminium.
18. Crystallised Aluminate of Magnesium and Silicium.
19. Manufacture of Adamantine Boron.
20. Plate of Crystals of Aluminium.
21. Blue Obsidian.
22. Obsidian coloured by Cobalt.
23. Samples of Crown Glass, extra white.

854f. Objective of Rock Crystal, 10 centimetres in diameter. *M. Lutz, Paris.*

854g. Astronomical Glasses, for cabinets of physics.
M. Lutz, Paris.

855. Micro-spectroscope. Spectral ocular with prism for comparing two spectra, and with Abbé's measuring apparatus for the direct estimation of the wave lengths of dark or bright lines in a spectrum. In case. *C. Zeiss, of Jena.*

This spectroscope gives the position of the bright or dark lines by means of a scale on which the spectrum is thrown, and which, by means of its peculiar

graduation and numbering, allows the wave lengths at any place to be read of in micro-millimetres.

856. Apps' Improved Gas and Electrode Holder for Spectrum Analysis. *Alfred Apps*

857. Improved Automatic Chemical Spectroscope, invented and made by the contributor. The object glasses and prisms by Chas. Owen, Optician. Strand.

Rev. Nicholas Brady, M.A.

Prisms with a circular face ted to the object glasses of the
collimator and telescope of the prisms being of the same
size as the object glass. ngular to the surface of the object
glass, and the refracting . The beam of light rendered
parallel by the collimating lens pa ough the first half prism perpen-
dicularly and suffers no refractic refracted on emergence from its
exterior face; the refracted and l beam is received on the external
face of a second object glass pris s more refraction and dispersion,
and, emerging at a perpendicular ce, is taken up and brought to a
focus by the object glass. In a ons the ray under examination
passes parallel to the base of the , and therefore at the angle of
minimum deviation. The variatio angle between the two prisms by
the motion of the tangent screw of scope merely brings one ray after
another into the field of view. This automatic arrangement gives a dispersion equal to one dense glass prism of 50°. Should greater dispersion be required I have arranged a prism of 60° in the centre of the instrument, which by a very simple automatic contrivance of one lever and a slot is moved by the arm carrying the telescope, so that any ray is still preserved at the angle of minimum deviation. A further advantage of this new principle is, that with these object glass prisms the field is completely filled with light, which has never usually been the case, unless the prisms are extra large, and therefore expensive; and if a train of prisms be inserted their faces only require to be equal for them still to entirely illumine the field: thus much light is gained, and comparatively little is lost by absorption and reflection, as the surfaces are fewer, so that the violet end of the spectrum is very extensive, and the lines beautifully defined.

858. Gas Lamp Apparatus for placing before the slit of the spectroscope with Bunsen burners, &c., insuring the proper adjustment of the platinum wires carrying the substance under examination in the flame without displacing the eye from the ocular of the telescope; and also an arrangement for quickly and efficiently exchanging one or both burners for either one or two vacuum tubes. *Rev. Nicholas Brady, M.A.*

Two photographs accompany the instrument, showing its use in two different positions.

859. Ordinary Spectroscope, arranged for the ex of diffraction phenomena, with aperture and gratings various kinds under common and polarised light, and means of observing the spectra of the diffracted beam. I and made by contributor. *Rev. Nicholas Brady*

b. POLARISCOPES, &c.

llett's Saccharometer, for the measurement of the ich certain fluids are capable of producing in the plane ion of the transmitted ray. *Rev. John H. Jellett.*

on is measured by the method of compensation, the original e plane being restored by transmission through a column of fluid opposite rotatory power. This fluid is contained in a vessel bottom with glass, and the length of the column is regulated by ube, also closed with glass, which is capable of moving in the ts axis, the amount of this movement being read off on a scale. ription of the instrument and of the analysing prism used in its is given in the "Transactions of the Royal Irish Academy," pp. 373–82.

Laurent Polarimeter and Saccharometer, with ıs on the plate, with inversion tube and one thermo- *Laurent, Paris.*

Saccharometer, by Soleil, with penumbra (large *M. J. Duboscq, Paris.*

arge Circle, by Messrs. Jamin and Sénarmont. *M. J. Duboscq, Paris.*

Large Circle for measuring the elements of elliptic y polarization in solids and liquids, and reproducing sions of polarization and refraction. (This apparatus the School of Photography.) *M. Lutz, Paris.*

olarising Apparatus, according to Dove's system, with polyoscope and dichroscope. *Schmidt and Haensch, Berlin.*

mple, handy Polarising Apparatus, according to m. *Schmidt and Haensch, Berlin.*

elde's Models, for illustrating the **colours of thin** polarised light. *Ferdinand Süss, Marburg.*

elde's Model, for illustrating **circular polarisation** f gypsum and scales of mica. *Ferdinand Süss, Marburg.*

aste-board Models, according to J. Müller's system, ting the **colour phenomena** in **polarised light,** i-axial and **bi-axial crystals.** *J. Wilhelm Albert, Frankfort-on-Maine.*

s of cardboard, together with a treatise on them. Described in "Lehrb. der Phys., 7 Aufl., I. Bd., 3tes. Buch, caps. 9 and 10."

olarising Apparatus, for projection with rotatory ccording to E. Mack's system, with quartz plate and $\frac{1}{4}$ plate. (Comp. Poggendorff's Ann., 1875, No. 12.) *J. Wilhelm Albert, Frankfort-on-Maine.*

The ray of sun or electric lamp falls through a Nicol, which is protected with a shade, upon a press, in which the object is fastened by means of spring clamps, and passes thence through a tube which can be rotated with great velocity. This tube is provided at one end with a shade capable of rotating with the tube, and the analysing Nicol over which there is a slit or a square aperture.

At the end of the tube is a deflection prism of crown glass, to which, for some investigations, a direct vision prism is added. The ray, as it issues from the tube, is received by a lens, which throws upon a screen a sharp image of the slit or square aperture. This image moves in a circle as the azimuth changes, and thus shows by quick rotation all the phenomena which, in ordinary polarising instruments, appear successively *side by side.*

868. Twelve Plates with Pictures, of gypsum and mica, for polarised light. *Professor Karsten, Rostock.*

The form of images has been chosen to represent the different colours of thin plates in polarised light. Any kind of polarising apparatus may be employed for these observations.

869. Nörremberg's Polarising Apparatus.
W. Apel, Göttingen.

870. Nörremberg's Polarising Apparatus, large size; according to the design of Professor Listing.
W. Apel, Göttingen.

(2.) The apparatus serves not only for purposes of lecture demonstration, but also for accurate measurements. The advantage of the instrument over the ordinary polarising microscopes lies in the circumstance that in the *Nörremberg* apparatus the polarised light passes to and fro through the same crystal plate. The movable glass plate of the middle table serves for measuring the angle of the optical axis by means of a graduated semicircle.

870a. Large Apparatus by Norremberg, improved by Wheatstone. *M. Lutz, Paris.*

870b. Telescope used for observing the **Polarisation of Light** in **Water.** *J. Louis Soret, Geneva.*

The telescope is closed on the objective side by a glass pane. The eyepiece is formed of a "Nicol" prism.

The observer, placed in a boat, immerses the objective end of the telescope and looks through the "Nicol." He then finds the light of blue coloration reflected by the lower strata on the surface of the water, and by turning the Nicol ascertains if it is polarised.

See "Notes sur la Polarisation de la Lumière de l'Eau." Archives des Sciences physiques et naturelles, 1869, Vol. 35, p. 84, and 1870, Vol. 39, p. 352.

871. Apparatus for the Observation and Measurement of the cyclopolar double refraction of Quartz in the direction of the optical axis. Designed by Professor Listing, executed by R. Winkel in Göttingen.

Royal Mathematical and Physical Institute of the University of Göttingen, Prof. Listing.

The telescope can, before being put into the holder of the apparatus, be adjusted for far off objects, or for an object of but 2–3 meters distance from the object glass. The *Fresnel* triple quartz prism is fixed in upright position in the support below the telescope, and protected by a cardboard shade against side lights. By means of the achromatic lens, situated below the prism, a virtual image is produced of an appropriate object (line cut by a diamond upon glass, &c.), placed upon the black table, which image, when seen sharp and double in the telescope, will be just as distant from the object glass of the telescope as the latter has been adjusted for. The magnitude of the duplication is read off from the micrometer in the ocular tube, and from the number obtained the diversion of the two rays after their passage through the triple prism is calculated. The ocular can now be provided with tourmaline and ¼ mica plate, which may be used singly or combined. The tourmaline alone, shows, on turning, in all azimuths, the double image without alteration of intensity in the compouent parts; the two rays undergo, therefore, neither linear (plain) nor elliptical polarisation. The tourmaline, with mica plate below it, shows, as well known, that both rays are circularly polarised, the one right, the other left; the tourmaline must in this case be so adjusted that its line of principal action be azimuth 0° or 90°, and the main section of the interposed mica plate is turned to form with that line $\pm 45^\circ$.

The aim of the measurements is to determine the refraction indices of the two rays of opposite circular polarisation, propagated with unequal velocity along the optical axis of the quartz.

872. Stauroscope, according to the design of F. von Kobell, executed by Bochur and Wiedemann.

Prof. Dr. Franz von Kobell, Munich.

873. Analysing Prism of Iceland Spar, made by the inventor, the late William Nicol, in his 80th year.

Edinburgh Museum of Science and Art.

The Nicol prism is so constructed that only one polarised ray can pass through it.

873a. A Nicol's Prism for Polarising Light, by C. D. Ahrens. *W. Spottiswoode, F.R.S.*

This, which is one of the largest ever constructed, has a clear field of 3¼ inches in diameter. With a view to saving bulk and weight, the acute angles have been cut off, and the whole reduced to an octagonal form. The advantages of this will readily be seen by comparing this instrument with that by Tisley and Spiller, the field of which is greater by only a quarter of an inch.

873b. A Nicol's Prism for Polarising Light, by Tisley and Spiller. *W. Spottiswoode, F.R.S.*

This, which is the largest and purest ever constructed, has a clear field of fully 3½ inches in diameter.

874. Soleil-Ventzke Polarising Apparatus, with several improvements. *Franz Schmidt and Haensch, Berlin.*

Soleil having introduced compensation by the use of rock-crystal, Ventzke subsequently improved the colour-giving power, and Scheibler made further improvements, principally in the manner of inserting the observation tubes. Messrs. Schmidt and Haensch, besides a few minor changes, succeeded in

making improvements which greatly facilitate the use of the instrument, by a change in the construction of the wedges, and have thus reduced the irregularities frequently observed in the polarisation of bodies of low specific gravities to from one to two tenths of a per cent. in each part of the scale. They have thereby done away with the principal cause of the variations which so frequently occur in the observations of different analysts.

875. Jellett & Corny Half-shade Polarising Apparatus, provided with wedge compensation.

Franz Schmidt and Haensch, Berlin.

This apparatus differs from the foregoing in having the double plate replaced by a double Nicol's prism. In using it both fields of the apparatus are adjusted to equal half darkness, instead of equal colour, as in the "Soleil." The double Nicol prism was first proposed by Professor Yelett, of Dublin, and employed by Professor Corny in Duboscq's polariscope for circular polarisation, known as saccharomètre à pénombre. The improvement in the instrument exhibited by Messrs. Schmidt and Haensch consists in combining with it their wedge-compensation, so as to obtain the advantage of lineal readings. The instrument recommends itself for dark solutions; it is indispensable for colour-blind operators, and it prevents the colour-weariness to which the healthy eye is liable. Its sensitiveness perceptibly exceeds that of a Soleil.

876. A Wild's Polari-Strobometer.

Franz Schmidt and Haensch, Berlin.

877. Jellett-Corny Polarising Apparatus, constructed for circular polarisation. *Franz Schmidt and Haensch, Berlin.*

878. Mica-preparations of mono- and bi-axial mica, for polariscopes. (See Mineralogy.) *Max. Raphael, Breslau.*

879. Mica-preparations of foliaceous mosses ("Laubmoosen"), Algal, &c., for microscopes. *Max. Raphael, Breslau.*

879a. Quartz Axis Plates. *M. Lutz, Paris.*

879b. Amethyst cut parallel to the axis. *M. Lutz, Paris.*

880. Dichroscopic Lens.

Four Nicol's prisms.
One Grazmowski prism.
Two Tourmlines parallel to the axis.
Fluor-spar of M. Bertrand's arrangement.
Quartz and mica for compensating the refraction of crystals.
Heated crystals, felspar, gypsum, carbonate of lead.
One blue glass, red glass, and violet glass.

Laurent.

882. Table Polariscope, made by the contributor when a youth. *Rev. Nicholas Brady, M.A.*

The interest of this instrument consists in showing with what simple materials a student can construct a fairly useful apparatus, the divided circles being common stamped protractors; the clamping screws, teapot thumbscrews, and the mountings of the lenses ordinary simple microscope frames.

882a. Original Apparatus for Rotatory Polarization, by Bit. *College of France, Paris.*

883. Airy's Polariscope, with appliances for approximately measuring the angle between the planes of polarization and analysation, and for determining the angle between the optic axis of biaxial crystals in air or in a fluid medium. Modified and arranged by the contributor when a student. *Rev. Nicholas Brady, M.A.*

883a. Large Polariscope for Projection, by Ladd. *W. Spottiswoode, F.R.S.*

A pair of Nicol's prisms, by Ladd, the first of a large size ever constructed. They are furnished with a system of lenses for showing the crystal rings, as well as with other contrivances for the various phenomena of polarised light.

883b. Revolving Analyser for Polariscope, constructed by Tisley and Spiller. *W. Spottiswoode, F.R.S.*

A revolving analyser, consisting of a double image prism, furnished with wheel-work, whereby it may be caused to revolve with such rapidity that the eccentric image may remain upon the retina during a complete revolution, and thus give the appearance of a ring of light. By this means all the phases of polarised light as seen successively in ordinary polariscopes may be seen simultaneously. The instrument is adapted to show all the phenomena of hromatic polarisation, both plane and circular. An instrument for a similar urpose was invented independently by Prof. Machs, of Vienna.

883c. A portable form of Polariscope, comprising a icol's prism, a double-image prism, a plate of tourmalin, a Savart's edge, a biquartz, and a quarter undulation plate. These various rts may be used either separately or in any combinations at asure; and are consequently adapted either to illustrate the eral laws of polarised light, or for actual observations of atmoeric or other polarisation not involving actual measurements. ill be observed that the tourmalin plate gives the opportunity sing convergent as well as parallel light. The size of the ument might, however, be reduced considerably below the nsions of the specimen here exhibited. *Mrs. W. Spottiswoode.*

3d. Large Circle for measuring the **Azimuths** of **Ellip-** d **Rotatory Polarization,** and reproducing all experi- of polarization and reflection. *School of Pharmacy, Paris.*

. **Arago's Polariscope.** *M. Lutz, Paris.*

Savart's Polariscope. *M. Lutz, Paris.*

Tourmalin Plates. *M. Lutz, Paris.*

De Sénarmont's Polariscope. *M. Lutz, Paris.*

884. Wheatstone's Polar Clock. To determine the true solar time by the polarisation of light reflected from the sky.

Wheatstone Collection of Physical Apparatus, King's College, London.

885. Latest form of Wheatstone's Polar Clock. To determine the true solar time by the polarisation of light reflected from the sky.

Wheatstone Collection of Physical Apparatus, King's College, London.

886. Polariscope and Set of Crystals.

Prof. W. F. Barrett, Dublin.

887. Norremberg's Polarising Apparatus, with Wheatstone's improvements. *H. Lloyd, Trinity College, Dublin.*

888. Duboscq's Polariscope, for determining the inclination of the axes in biaxial crystals.

H. Lloyd, Trinity College, Dublin.

889. Wheatstone's Apparatus for illustrating the laws of interference of polarised light.

H. Lloyd, Trinity College, Dublin.

III.—PHOTOMETERS.

891. Great Atmospheric Photometer. A De la Rive model, designed by M. Thury, and constructed by the Geneva Association for Constructing Scientific Instruments.

De la Rive Collection. The property of Messrs. Soret, Perrot, and Sarasin, Geneva.

This apparatus is particularly intended to measure the transparency of the atmosphere. It is used for simultaneous observation, with one eye, through two similar reflectors placed at different distances. The difference of brightness and of tint between the two reflexions indicates the effect of the interposing stratum of air. The computation of this difference is arrived at by equalising the two reflexions by means of diaphragms of different apertures, and of glass plates variously tinted. The instrument is composed of a telescope with a single eye-piece, and two objective tubes, of which the angular distance varies at will between 0° and 29°. A system of four full reflecting prisms unites the two divergent cones in the eye-piece. The apparatus is movable round three different axes, and may be worked in the most varied directions. Graduated circles measure these diverse angular motions. It is a general photometer, and can be specially used as an astronomical photometer. De la Rive has effected with it a long series of observations on the transparency of the air. (See Comptes Rendus, vol. 63, p. 1221.)

892. Photometer, according to Glan's system, for photometrical determination of the absorption spectra for homogeneous light. *Schmidt and Haensch, Berlin.*

892a. Photometer, fitted with clock, governor, pressure gauge, and all necessary apparatus complete, as adopted by the Government of Canada. *William Sugg.*

893. Photometer by **Bunsen,** simplified by Professor Bohn. *Physical Collection of the University of Giessen, Professor Buff.*

The standard for comparison is a pure stearine candle of known weight. The measure wound upon the cylinder serves to determine the distance at which the oil spot on the paper, when viewed from the second flame, is brought to disappear. First the standard candle, and then the flame, to be measured, are thus investigated. The intensities of the two lights are to one another as the squares of their distances from the oil spot.

894. Photometer, for ascertaining amount of daylight. *Scottish Meteorological Society.*

The light is reduced by turning round the graduated milled head at the side, which works simultaneously and by equal degrees the two shades which thus reduce the area of the aperture. At the opposite end of the box a printed page is looked at through the eye-piece till it ceases to be legible, when the result is read off in revolutions of the milled-head. Designed by Thomas Stevenson, C.E., F.R.S.E., Honorary Secretary, and described in Society's Journal, vol. iii., page 292.

895. Selenium Photometer. *Siemens and Halske, Berlin.*

It being the property of selenium that its electrical resistance is diminished by the action of light, the diminution being proportional to the intensity of the light, this apparatus is constructed with a plate of selenium forming part of an electric circuit which is brought by rotating the cylinder containing the plate alternately under the action of a normal candle sliding on a scale and of the light to be measured. The normal light is adjusted on the sliding scale until the electrical resistance of the selenium remains constant under the action of the two sources of light, and the intensity of the light to be measured is calculated from the relative distances of the lights from the selenium plate.

897. First Heliostat, invented by 'sGravesande. *Professor Dr. P. L. Rijke, Leyden.*

(*See* 'sGravesande's "Physices Elementa Mathematica," ed. III., Tom. I., page 715.) 'sGravesande was an eminent Dutch geometrician, b. 1688, d. 1742.

898. Heliostat, G. Johnstone Stoney's modification, made by Spencer and Sons, Dublin, a cheap and useful form. *Prof. W. F. Barrett, Royal College of Science for Ireland, Dublin.*

IV.—RADIOMETERS.

899. A Collection of Radiometers of different construction, with lamps and screen for making experiments. *Professor Adolph Weinhold, Chemnitz.*

The apparatus serves to perform the radiometer's experiments, described by the exhibitor in *Carl's* "Repert. der Experimental Phys., 1876, Heft 2." Compare also the description annexed to the apparatus.

900. Some new Radiometers. *Dr. H. Geissler, Bonn.*

901. Radiometer. *John Browning.*

These instruments are set in motion by either light or heat; they consist of four small discs on two arms at right angles to each other; the discs may be of pith or mica; those exhibited are made of mica, as they appear to be the most sensitive to minute traces of light. One side of each disc has a dead black surface. The action of light or heat repels the black surfaces, and continuous motion is obtained so long as any light or heat falls on them.

902. The late Prof. J. J. Müller's Apparatus for illustrating the influence of the intensity of light on its rapidity of propagation (Poggendorff's Annalen, 1872, cxlv. p. 86.)

Professor A. Mousson, Zurich.

Use is made of Newton's rings, produced between a plane glass *a*, and another glass *b* (the latter very slightly convex), which may be removed (in a known manner) so as to produce differences of progression up to 50,000 waves. At this distance, the convex glass *b*, on which *a* rested at first, radiates in the centre of a square iron vessel *c* on mercury. The three screws of the support *d* which surrounds the glasses are fixed apart. Then, the mercury having been allowed to flow out (through the cock *h*), *c* is brought down and fixed also, by means of three other screws *y*. The distance can be calculated with great precision by means of the weight of the mercury, and the known area of the vessel *c*.

The luminous point used is the small image at the opening of a collimating tube *e*, lighted by a flame ("flamme de Soude"), upon the hypothenuse surface of a small prism *f*. From this point the rays diverge and fall on the lens *g*, placed on the glass *c*, which makes them parallel. These rays return, with interference, from the two reflecting faces, towards the point *f*, where the eye is placed close to the prism.

Now, if the intensity of the light be lessened by interposing absorbing glasses, it will be seen that the greater the difference in the number of waves the more the lines change place, the increase of rapidity being proportionate to that of intensity.

V.—REFLECTION, REFRACTION, AND DIFFRACTION.

903. Total Reflection Apparatus, for the projection of objects placed in a horizontal position.

T. and A. Molteni, Paris.

904. Small Prism for double reflection. *Laurent.*

905. Coloured Rings on an 80 millimetre tripod.

Laurent.

905a. Fresnel's Parallelopiped. *M. Lutz, Paris.*

908. Apparatus designed to exhibit Double Reflection, which arises when a ray of light traversing a uni-axial or bi-axial crystal reaches the surface of contact of the crystal with the surrounding medium. *Arthur Hill Curtis.*

The incident light passes through a small orifice in the cap terminating one of the tubes. If the eye be applied to the other tube, as the stage on which the crystal rests is turned round its vertical axis, four, three, or two images of the orifice will be seen formed by the two rays which, refracted at the upper surface, are (in general) *each* doubly reflected at the lower surface. A Nicol's prism is added, which, though not essential to viewing the phenomena, may be introduced into *either* tube to polarise the incident light, or to examine the planes of polarisation of the reflected rays.

908a. A large Mass of Iceland Spar, polished to exhibit the optical properties of the crystal in directions parallel and perpendicular to the optic axis, and in directions perpendicular to the cleavage plane 100, and to the plane 122 correlative with it. Worked and polished by Mr. Ahrens.

Professor N. I. Maskelyne, F.R.S.

909. Extra Dense Flint Prism, of 60°, surface 4 by 3 in.

A. Hilger.

910. Iceland-spar Prism, of 60°, showing single refraction for any line in the spectrum. *A. Hilger.*

911. Prism, with Double Reflector, of Dr. de Wecker. Two triangular prisms are joined together at their hypothenuse; while the direct observer looks through the cube formed by the union of the two prisms, an incidental observer sees in the hypothenuse the same reflection as though in a mirror. The $2\frac{1}{4}$ lens serves to show the reflection smaller and reversed.

M. Crétès, Paris.

912. Prism, Moveable, by Crétès. Two prisms of 15° each are placed in a setting. When placed basis on edge, their refraction becomes annulled: (15—15=0). When placed basis upon basis, their effect becomes added: (15+15=30). Between these two extremes, an ascending scale of 0 to 30° can be obtained. The prismatic axis remains fixed, because the glasses move in reverse ways and in equal volume. *M. Crétès, Paris.*

912a. Three Rectangular Prisms, crown glass.

M. Lutz, Paris.

912b. 32 Rectangular Prisms, flint glass of various sizes.

M. Lutz, Paris.

912c. Prisms for Camera. *M. Lutz, Paris.*

912d. Prisms with Compartments. *M. Lutz, Paris.*

1st arrangement. For objective, the réseau on smoked glass is used, and for the eye-piece, a common eye-piece. Looking at a jet of gas (for instance) at seven metres distance, the deviation of the objective and the eye-piece being from 34 to 41 centimetres (pull one of the tubes), the reflection of the jet is seen reversed, and coloured more or less. By shortening the glass as much as possible, the second reflection is seen green-coloured.

2nd arrangement. A common objective is used, and for eye-piece, the small photographic réseau. The deviation from the objective to the eye-piece being of 50 centimetres (maximum width of the telescope), the reflection of the gas jet, reversed, is obtained as in an astronomical glass. By shortening the glass to 31 centimetres, the direct reflection is got as in the Galileo telescope. (*See* Mémoire sur les Phénomènes de Diffraction produits par les Réseaux circulaires, Archives des Sciences physiques et naturelles, 1875, vol. 52, p. 320.)

916. Refractometer, according to **Abbé's system,** for determining the refractive indices, and the dispersion of any kind of liquids. *Carl Zeiss, Jena.*

The refractometer enables one to determine the refraction index of a liquid with a single drop of the substance up to four decimals. The indications refer to line D, and are directly read off from a graduated sector.

917. Procentum Refractometer, for determining the percentage of solutions and mixtures by optical means.

Carl Zeiss, Jena.

The instrument is designed for liquids whose index lies between 1·3 and 1·4. The determination takes place at a numbered scale in the field of view of a small telescope. Besides the scale for the absolute index of refraction, there is another scale, which gives directly the per-centage strength of saccharine liquor.

917a. Refractometer by M. Jamin.

Polytechnic School, Paris.

917b. Jamin's Interferential Apparatus with two Spars. *M. Lutz.*

917c. Refraction Goniometer, constructed by the Rev. Baden Powell, and used in some of his experiments, and afterwards by the Rev. T. Pelham Dale and Dr. Gladstone in their earlier researches on refractive indices of liquids at different temperatures. *Mrs. Baden Powell.*

918. Apparatus for demonstrating the **Refraction of Light** in liquids, according to J. Müller.

J. Wilhelm Albert, Frankfort-on-Maine.

The semicircular plate of the refraction apparatus is of glass, ground on its outside and having the scale burnt into it in black. The ray refracted from the liquid appears therefore on the outside of the graduated plate and can thus be viewed by larger audiences.

919. Abbé's Refractometer, for determining the power of refraction of different liquids as far as the fifth decimal, with direct

reading of the refractive index, without calculation. (Comp. Abbé: "Neue Apparate.")

Franz Schmidt and Haensch, Berlin.

920. The same, smaller model.

Franz Schmidt and Haensch, Berlin.

921. Apparatus, according to J. Müller's principles, **for experiments as to the refraction of rays of light in fluids,** all of glass. *Warmbrunn, Quilitz, and Co., Berlin.*

921a. Apparatus by M. Mascart for studying the refraction of gas. *M. Mascart, Professor at the College of France.*

921b, Apparatus for determining the Refraction Index of Solids and Liquids.

C. Czechovicz, teacher of Physics at the Gymnasium of Belostok, Russia.

Consists of a horizontal board and vertical divided pillar with movable support for a telescope. The body under examination is put on a glass plane attached over a slit in the board, through which a light beam is reflected by an inclined mirror. A linear mark made on the upper surface of the glass (if the body is solid), or on the upper surface of the vessel (if the body is liquid), is brought in coincidence with a movable wire which touches the upper plane of the body. The distance of this wire and the height and inclination of the telescope give the necessary data for calculating the index with sufficient approximation.

VI.—FLUORESCENT BODIES.

922. Fluids showing the **Phenomenon** of **Fluorescence.**

Charles Horner.

1. Soda salt of anthracene in water.
2. Fluorescine in water.
3. Eosine in water.

923. Fluids showing the **Phenomenon** of **Fluorescence.**

Charles Horner.

Small Tubes in Stand.

Turmeric in castor oil.
Harmaline in water.
Magdala red in alcohol.
Ebony wood (*Amerimnum ebenus*) in castor oil.
Aniline in chloroform.
Esculine in water.
Camwood (*Baphia nitida*) in castor oil.
Esculetine in water with alkali.
Fraxine (*Fraxinus excelsior*) in water.
Fustic (*Maclura tinctoria*) in solution of alum.

962b. Actinometers, or instruments for ascertaining the ntensity of the action of the light, and by which the exposure of he sensitive pigment paper under the negative is regulated.

Johnson's, Vogel's, Spencer's, Lambert's, Sawyer's, Burton's, Vidal's. *The Autotype Company.*

Chemicals Employed.

Granulated bichromate of potash. Chrome alum.

Colours.

Indian ink, vegetable black, Paris black, plumbago, Indian red, Venetian ed, vermillion, purple madder, brown madder, vandyke brown, indigo, lac de rin, various kinds of gelatines.

962c. Pigmented Papers, in various colours, with subjects printed to show the various shades.

962d. Transfer Papers (*i.e.*, papers prepared with insoluble gelatine, and upon which the pictures finally rest).

962e. Sawyer's Patent Flexible Support (being paper prepared with insoluble gelatine and an aqueous solution of lac, upon which the picture is first developed previously to its transfer o the final support. *The Autotype Company.*

962f. Reversing Mirror, being a piece of plate glass polished to a perfectly true plane, and silvered by a chemical rocess used to produce *reversed* negatives, enabling them to be inted by the single transfer process of permanent pigment inting. *The Autotype Company.*

962g. Wave Bath, for nitrate of silver solution (being a new l convenient form for sensitizing large plates with a compara- ely small quantity of solution. *The Autotype Company.*

962h. Sawyer's Callotype Process.

The Autotype Company.

ass plates prepared with gelatine and isinglass, potassium dichromate, hardened by a spirituous extract of gum resins, upon which the photo- is impressed by the action of light; after which they are placed in a rinting press, damped, and inked by lithographic rollers.

a.) Plate in first stage of preparation.
b.) Plate ready for exposure under negative.
.) Plate after exposure under negative.
.) Plate after being inked up in the press.
) Plate with the same picture partly showing on the paper and partly on the plate.

i. **Four Prints from Photographs,** by Paul Pretsch's ical process. *Robert Sabine, Regent's Park.*

VIII.—EDUCATIONAL.

963. Two Frames with 126 Photographs on Glass, for projection by the lantern, for instruction in the natural sciences.
Romain Talbot, Berlin.

964. Four simple Models, for instruction in the use of the telescope and the microscope.
J. W[illegible]lm Albert, Frankfort-on-Maine.

The four models for optical instru[illegible]on are open instruments with lenses and shades. They show the course of [illegible] rays and illustrate in a simple manner the Galilean, astronomical, and [illegible]rrestrial telescopes, and the compound microscope.

These models are largely used in German and foreign educational institutions.

965. Coloured Chalks for lectures, with a Black Board.
C. Blattner, Munich.

966. Interference Apparatus by Fresnel, executed for educational purposes by Ch. Jung, Giessen.
Physical Collection of the University of Giessen; Professor Buff.

967. Handy Educational Apparatus, for fundamental experiments on **Refraction.**
Professor Dr. J. J. Oppel, Frankfort-on-Maine.

This apparatus is only a modification of the old experiment of viewing a coin at the bottom of a basin full of water. The coin is replaced by a white line upon black ground, and the water through a movable cube of gla[illegible] The position of the eye is fixed by a dioptric plate.

968. Handy contrivance for illustrating **astronomical refraction** and its effect on measured heights of stars.
Professor Dr. J. J. Oppel, Frankfort-on-Maine

The eye looks through a dioptric plate over a wooden globe ("earth[illegible] towards a few stars and the rising moon, which appears above or below the horizon, according as the piece of glass, which represents the refracting atmosphere, is lifted up or removed by means of a contrivance attached to it

969. Two Colour-tables, for illustrating "colour blindness," with greenish glass (absorbing the ends of the spectrum) belonging to them. *Professor Dr. J. J. Oppel, Frankfort-on-Maine.*

Both tables, each with 10–12 colour-couples upon black ground, have references to the most frequent form of achromatopsy, the so-[illegible] respectively *green*, blindness The one table contains colour-coup[illegible] are most generally mistaken for one another; the other such that are [illegible] mistaken. The green glass, added to the tables, enables a normal eye [illegible] an idea of the correctness of the preceding statements.

970. Apparatus for illustrating the Colours of double refracting Bodies, in the form of a Gothic window, composed of gypsum plates systematically arranged according to the colours; with a blackened glass plate belonging to it.

Professor Dr. J. J. Oppel, Frankfort-on-Maine.

971. Some characteristic Drawings for illustrating the **Stroboscopical Principle,** with manifold movements, as,—forwards and backwards, centripetal and centrifugal, undulatory, oscillatory, and quite irregular.

Professor Dr. J. J. Oppel, Frankfort-on-Maine.

Is a collection of those principal forms of periodic movements which can be represented stroboscopically.

IX.—MISCELLANEOUS.

971a. Wheatstone's Apparatus. *Paris Observatory.*

971b. Interferential Apparatus, by Arago.

Paris Observatory.

971c. Curve for obtaining **Wave-lengths** of **Spectra;** and **Map** of the absorption spectra of bromine and iodine monochloride.

Professors Roscoe and Thorpe.

972. Mixoscope (colour-mixer), executed according to the directions of the contributor by M. Ph. Edelmann, Munich.

Prof. W. von Bezold, Royal Polytechnic School at Munich.

This apparatus permits the preparation of the true mixing colour of two colours by actual trial with the brush, and thus a correct colour table can, by its means, be made with greater facility than with Newton's disc. The achromatised calcspar prism is so to be adjusted that on looking through the apparatus only six squares should be visible. It is easy to find this position through moving the telescope and turning the prism. On bringing the two colours to be mixed under two of the square openings, these colours will be right and left of the mixed colour, which fills the middle part of the three contiguous squares. If, now, the other two apertures contain the optical true mixed colour, the two central squares will appear in the same tint.

Compare the description annexed to the apparatus.

973. Clockwork for colour discs, for lectures with discs, according to Kühne's and Becker's principles.

Rud. Jung, Heidelberg.

The clockwork, provided with a strong spring, is capable of rotating coloured discs of 28 centim. diameter with such velocity that a disc covered with the tints of the spectrum will appear white. By a simple contrivance the

978a. Apparatus for measuring the magnitude of Gas Jets at a distance. Invented by Mr. C. Wolfberger.

Geneva Association for Constructing Scientific Instruments.

This apparatus, invented by the civil engineer Wolfberger, is intended for the surveying, from the street level, of gas lamps.

Founded on the principle of the sextant, it is composed of two mirrors: the one fixed, the other movable parallel to the first along a graduated scale.

In order to measure the magnitude of the gas jet, the operator holding the instrument by its handle on a level with the visual ray, and looking through the diaphragm, sights simultaneously in a direct line the jet to be measured, above the fixed mirror, and indirectly the reproduction of the same jet by double reflection. The swivel placed below the handle is then turned, until the right edge of the jet, seen in a direct line, coincides with the left edge of the jet, seen by reflection. The magnitude of the jet, or flame, ascertained, is then shown on the metallic scale which is reckoned in millimetres.

978b. Patent Illuminating Power Meter, for showing the illuminating power of gases in the terms of the Parliamentary sperm candles and the standard quantity of five cubic feet of gas per hour by the observation of one minute. *William Sugg.*

979. Trepiscope. An optical machine made by the late Richard Roberts, of Manchester, and first shown at the meeting of the British Association at Dublin in 1835.

The Committee, Royal Museum, Peel Park, Salford.

The machine being turned by hand or by power will cause the card on the disc to revolve from 6,000 to 40,000 times a minute; on viewing the revolving disc *through the eye-hole*, the printing on the card can be read with ease and distinctness.

The time given for one view of the card does not exceed the 150,000th of a second when the disc is revolving at the highest speed.

979a. Phosphoroscope, by Becquerel.

M. J. Duboscq, Paris.

980. Radiograph.

The Committee, Royal Museum, Peel Park, Salford.

A small machine to show that the spokes may be counted whilst the wheels revolve at a very high velocity, probably the highest attainable. Invented by the late Richard Roberts, C.E., of Manchester.

981. Newtonian Disc, for rotating movement transmitted by caoutchouc bands. *Luizard, Paris.*

981a. Newton's Apparatus. *M. Lutz, Paris,*

982. Clock for producing Eclipses in groups, on Sir Wm. Thomson's plan in azimuthal condensing lights, by periodically dropping a screen over the flame.

Chance Brothers & Co., Birmingham.

[illegible]r of **Reflectors,** for the demonstration of the law [illegible].

Elliott Brother

983a. Reflector of 22 mm. diameter, for Foucault's telescope

M. Lutz, Paris

983b. Apparatus illustrating Persistency of Vision.

Sir F. Pichler

SECTION 8.—HEAT.

West Gallery, Upper Floor, Room Q.

I.—SOURCES OF HEAT.

4. **Double-Chambered Lamp and Reservoir** for heat- ater or air, or both. There is no blast-pipe, or communi- i between the chambers. *J. L. Milton.*

heat is generated by the combustion of methylated spirit, and applied principle of driving a ring of flame from the holes in the top of the hamber against the flame issuing from the inner compartment, thus ig a great and continuous heat. The spirit in the inner chamber alone s to be lighted. A chambered and tubed reservoir accompanies the The consumption of 1 oz. of methylated spirit in the outer, and ½ oz. inner chamber, will produce and maintain, for from 10 to 15 minutes, it a heat for a vapour-bath as most persons can bear.

5. **George's Patent Gas Calorigen,** for warming and lating apartments. *John F. Farwig.*

peculiarity of construction in this gas stove, which diffuses heat prin- by convection, consists of an outlet so arranged with regard to the (both being external to the apartment) that only so much air passes way as is required to support and carry off the products of istion.

heat generated by combustion warms a thin coil of sheet iron in the ır of the stove, the coil being in communication at one end with the al atmosphere, and at the other with the apartment; thus a stream of air, which is warmed in its passage, is drawn into, and equally diffused ghout, the apartment.

16. **Bunsen Burner,** improved form, with air jet to increase temperature of the flame to any required extent without justment of height or position. *Thomas Fletcher.*

he above, the blow-pipe flame obtained with the blast tube, when confined loose cap, is compact and very powerful, owing to the partial mixture before the blast begins to act.

17. **Patent Injector Gas Furnace,** with blower, for the ment of refractory substances at very high temperatures. *Thomas Fletcher.*

s furnace will burn perfectly in the same space any available gas supply 10 to 50 ft. per hour, or more, if required, giving temperatures in exact tion. With ½ inch gas supply, day pressure, starting with a cold e, silver can be melted in three minutes, cast iron in eight minutes, and

997. A Gas Lamp, consisting of four Bunsen burners, and provided with an air-regulating system.

S. Hoogewerff, Dr. Phil., at Rotterdam.

This lamp, which is intended for heating tubes, was constructed by Mr. Verkerck, mechanical engineer, at Utrecht, under the directions of Dr. Hoogewerff, and belongs to the middle school at Rotterdam.

998. A Gas Lamp (Bunsen's system), intended for heating porcelain vessels of la[illegible]

H[illegible]f, Dr. Phil., at Rotterdam.

It was constructed, under the dir[illegible] Dr. Hoogewerff, by Mr. Verkerck, mechanical engineer, at Utrecht, [illegible]ongs to the middle school at Rotterdam.

999. Apparatus fo[illegible] **liberation of heat** during solidification. *Will. Isaac, [illegible] am Rennweg, Thüringen.*

II.—THERMOMETRY A[illegible]D PYROMETRY.

1000. Thermometer. "The Great Pyramid temperature scale, and its standard reference point of 50° P." With a map of the world to illustrate the advantages of this standard.

Prof. Piazzi Smyth, Royal Observatory, Edinburgh.

This consists of a large table thermometer, graduated according to the indications of the Great Pyramid system of standards; firstly, by colours into fifths of the distance between freezing and boiling of water, and then each fifth into 50, or 250 for the whole distance.

A map of the world on an equal-surface projection accompanies the thermometer, and exhibits the mean temperature of the whole earth's surface according to the Great Pyramid scale; illustrating also the territorial and international advantages to all civilised nations of adopting the mean temperature standard of the Great Pyramid, viz., 50° Pyr. or 68° Fahr., as the temperature reference standard for all human purposes, scientific, social, and commercial.

1001. Legible Spirit Thermometers, with line at above and below the proper temperature of a room, so that the degree can be read off at a long distance, at the opposite side of a large room, or at the ceiling, for experiments in ventilation.

Peter Hinckes Bird, F.R.C.S. Lond.

1002. Apparatus for determining the **Boiling Point** of a **small quantity of Fluid.**

The Secondary Government School, Assen (Neth[illegible]).

In this simple apparatus, constructed after the design of Dr. A. V[illegible] (teacher at school for middle-class education at Assen), the little tu[illegible] for the greater part with mercury; the remaining space with the fl[illegible] tube is then turned upside down into a small beaker-jar, which is [illegible] with mercury; part of this must be removed until the quantity left [illegible]

ıetres above the bottom of the jar. When the apparatus has e large beaker-jar, water or oil is poured into the latter, so quite immersed. The jar is then heated, agitating the fluid ı moving apparatus.

scale serves to determine the height of the fluid in the great ı the difference between the position of the mercury in the at on the outside of it. With respect to determining this essure of the fluid in the great beaker-jar and the barometric aken into consideration. Thus, when the pressure of the fluid er-jar is equal to half a centimetre of mercury, and the baro-$\frac{1}{3}$ centimetres, the thermometer must be observed, when the ıbe is 1 centimetre higher than that at the outside of it.

her a fluid is homogeneous, two experiments must be made, which is partially evaporated. In both cases the results ?.

our of the fluid in the tube has the pressure of one atmosphere of the fluid must be observed.

ɔtographs of Old Thermometers; a small al-ıneter, with Florentine scale, and four larger ones by rest (1754).

sor Hagenbach-Bischoff, Director, The Physical itute in the Bernoullianum, Basle.

ıol thermometers zero indicates the temperature of the cellar vatory of Paris, and 100° the boiling point of water.

ɔugh for comparing Thermometers, provided ɔut-flow tubes for water, and stirring apparatus.

V. Gunning, Professor of Chemistry at the "Athe-illustre," Amsterdam.

eters are placed in a loose frame, in which they may be trans-trough into another containing water of another temperature. s of glass, placed on either side of the frame, prevent the the water from cooling.

l Thermometer, designed by L. R. Brülme, Leyden.

de Loos, Director of the Secondary Town School, den.

ıeter is intended to admit of a large number of students seeing, the change in the volume of the mercury as the temperature

y is a small glass tube, balanced by another similar tube, both ether by a thread, which is suspended over a small copper box, of which is a needle moving over a screen (or dial).

rcury expands, the first glass tube rises, and the needle moves. e the tube descends.

ɪrcurial Dial Thermometer, adapted for class ın specific and latent heat.

Prof. W. F. Barrett, Dublin.

n of the mercury in the bulb of the thermometer lifts a small ːh communicates its motion to the index hand. Small varia-

tion erature are thus readily seen by a large class, *e.g.*, the expansion of the g... of the bulb causing a momentary retreat of the index hand, is seen to be the first effect produced by heat on the bulb. By making the scale on glass the dial can be projected on a screen and determination of specific and latent heat made before a large class; electric contact can also be made by the hands, and thus a self-registering thermometer constructed. The instrument was made by Mr. Yeates, of Dublin.

1011. Various Thermometers, of different kinds, in metal, ivory, porcelain, glass, and wood *Elliott Brothers.*

1012. Standard Ther... r. *Elliott Brothers.*

1013. Insolation Therm... ter, for determining the intensity of the rays of the sun (maximu...m thermometer), with holder. *...h. F. Geissler & Son, Berlin.*

1014. Eight Normal ... meters, executed by Greiner and Geissler, Joint Stock (... , Berlin.
Imperial Admiralty Hy... raphical Bureau at Berlin, and Deutsche Seewarte in Hamburg.

These thermometers are employed in the stations of the Naval Observatory and in the Imperial Navy.

1015a. Thermometer, with corrected Freezing Point. *W. Gloukhoff, St. Petersburg (Russia).*

This thermometer is constructed on a principle much used in Germany. To it is added only a contrivance to render the scale more steady, and to correct the error of *freezing point*, by raising or lowering of the scale. By unscrewing the upper metallic cap of the thermometer, this contrivance becomes visible.

1016. Reaumur's Scale. *Dring and Fage.*

Formerly much used in Germany and Russia, now mostly in Norway and Sweden, and some parts of Denmark. The zero of this scale is at the point of melting ice. The interval between this and boiling point is divided into 80 degrees.

1017. De Lisle's Scale. *Dring and Fage.*

This scale is seldom used; zero is fixed at boiling point; the interval between this and freezing is divided into 150 degrees.

1018. Six's Thermometer on a porcelain scale (named after its inventor, Mr. Six of Canterbury) for registering extremes of temperature. *Dring and Fage.*

The indices are little pieces of steel coated with glass which are enabled to retain their position in the tube by means of a hair fastened round them, and by this means the highest or lowest temperature is recorded.

1018a. Six's Thermometer with a very flat bul... renders it as sensitive as an ordinary mercurial thermome...
S. G.

1018b. Six's Thermometer with mercurial wet bulb thermometer attached, thereby combining four instruments in one, namely, maximum, minimum, hygrometer, and present temperature. *S. G. Denton.*

1019. Long Brass-Cased Thermometer. Showing the difference in length of the mercurial column after being pointed and divided with the whole length of the tube immersed in water at the various temperatures between 32° and 212°; the same with the bulb only in the water. *Dring and Fage.*

1020. Very delicate Spiral Bulb Thermometer. Extremely sensitive, capable of indicating small variations of temperature. *Dring and Fage.*

1022. Standard Thermometer, calibrated throughout. *Dring and Fage.*

A standard thermometer divided on the tube, used for purposes where great accuracy is required. The tubes used for these thermometers are selected with great care, particular attention being paid to the uniformity of the bore. The method of ascertaining this is usually performed as follows:— A portion of mercury is introduced into the tube, and the length it occupies is noted; it is then carried a little further on, and its length compared with the former length. So on all down the tube; if the length has decreased from the first measurement, it shows that the bore of the tube has increased, and vice versâ. The process is known as calibration.

1023. Four Thermometers. Showing the different scales principally in use. Fahrenheit, Celsius or Centigrade, Reaumur, and De Lisle. *Dring and Fage.*

Fahrenheit's scale is used principally in Great Britain, its Colonies, and the United States. The zero of this scale is obtained from a mixture of salt and snow; thirty-two degrees is the point at which ice begins to melt, and 212, or boiling point, from boiling water, when the barometer stands at 29·905. One advantage of this scale is that temperatures may often be expressed in whole degrees, whereas in other scales fractions of degrees are frequently necessary.

1024. Celsius or Centigrade Scale. Generally used on the continent. *Dring and Fage.*

The zero of this scale is that point at which ice begins to melt, and 100 the point at which water boils when the barometer stands at 760mm. Celsius is the name of the inventor of this scale; it is called Centigrade from its being divided centesimally.

1025. Becquerel's Thermo-Electric Thermometer. *Conservatoire des Arts et Métiers, Paris.*

1025a. M. Becquerel's Thermo-Electric Pyrometer. *Conservatoire des Arts et Métiers.*

1026. Hodgkinson's Actinometer. Actinometer by the Rev. G. C. Hodgkinson, described in the Proceedings of the Royal Society, vol. XX., p. 328. *Kew Committee of the Royal Society, Kew Observatory.*

It is a large thermometer, filled with alcohol coloured blue, and having a bore much contracted for a great part of its length, in order that the scale

may be very open at its top; it opens out into a large chamber, which receives the superfluous fluid at the time of observation.

A tin case, capped at both ends, prevents the access of extraneous rays to the bulb of the instrument at the time of observation.

1027. Original Spirit Thermometer, of the Florentine Accademia del Cimento (17th century).

The Royal Institution of Great Britain.

Presented to the Royal Institution by Sir Henry Holland, Bart., F.R.S.

1028. Drawings, various tly new, of constructions of Differential Atmospheric Ther ters.

Dr. Leopold Pfaundler, Professor of Physics at Innsbruck.

This plate presents a general view of all possible forms of construction, which partly appear as modifications of Berthelot's atmospheric thermometers, partly are based on independent principles.

For further details, see Transactions of e Imperial Academy of Sciences at Vienna, Vol. LXXII., 1875.

1029. Melloni's Thermo-Electric Apparatus.

M. Ruhmkorff.

1029a. Line Pile for Spectrum and Galvanometer.

M. Ruhmkorff.

1030. Galvanometer for Thermo-Electric Currents.

Luizard, Paris.

1031. Pyrometers and Thermometers.

Conservatoire des Arts et Métiers, Paris.

1032. Collection of Thermometers.

Dr. H. Geissler, Bonn.

1033. Thermo-Electric Alarum, for giving notice when a given temperature is reached. *Dr. Letts.*

The apparatus consists of an open thermometer with large bulb and wide tube. A platinum wire is sealed into the bulb, and another wire passes down the tube. The latter can be so adjusted that at a given temperature its end is touched by the mercury in the tube. The two wires being connected with an electric bell and battery, as soon as the mercury touches the wire, contact is made and the bell rings.

The apparatus was used in experiments with the glass digester, and served to give notice at some distance from the room in which the latter was being heated when the desired temperature had been reached, thus rendering an actual observation of the temperature unnecessary, and so preventing all danger in case of an explosion.

1034. Normal Thermometer, divided in tenths of a degree from 0° to 105° C.

Will. Haak, Neuhaus am Rennweg, Thüringen.

1035. Normal Thermometer, in a narrow glass c with a small mercury bulb: divided in tenths of a d to 105° C. *Will. Haak, Neuhaus am Rennweg,*

1036. Normal Thermometer, divided in tenths from $-35°$ to $+50°$ C. *Will. Haak, Neuhaus am Rennweg, Thüringen.*

1037. Two Thermometers, on the plan of Virchow, for physiological investigation.
Will. Haak, Neuhaus am Rennweg, Thüringen.

1038. Two Thermometers, for chemical work, from $-10°$ to $+360°$. *Will. Haak, Neuhaus am Rennweg, Thüringen.*

1039. Two Thermometers, from 100° to 360°.
Will. Haak, Neuhaus am Rennweg, Thüringen.

1040. Two Thermometers, from 0° to 150°.
Will. Haak, Neuhaus am Rennweg, Thüringen.

1041. Two Thermometers, with divisions etched on the tube. *Will. Haak, Neuhaus am Rennweg, Thüringen.*

1042. Two Thermometers, for medical purposes, on the plan of Traube, divided in tenths from $+25$ to $+45°$ C.
Will. Haak, Neuhaus am Rennweg, Thüringen.

1045. Various Pressure Thermometers, on the plan of Mitscherlich. Consult the adjoined pamphlet.
Prof. Mitscherlich, Münden.

1046. Suture Thermometer, on the plan of W. Beetz, constructed by Sauerwald, of Berlin. Consult the adjoining description and scheme. *Prof. Beetz, Münich.*

1047. Model of an **apparatus for measuring temperatures by means of thermo-batteries.**
Dr. T. Pernet, Breslau.

The apparatus permits the quick and reliable determination of the temperature of the several soldered places, as well as the differences of temperature of any two soldered places.

In the first case the resistances of the single conductors (except the resistances of the two soldered places, which are exposed to constant temperatures, and show always the same resistance) may be different. In the other case the resistances of all soldered places must be capable to be made equal.

1048. Diagrams, illustrating the application of the **apparatus for the measurement of the temperature of the earth** and of metal tools. *Dr. T. Pernet, Breslau.*

1049. Normal Thermometer, divided in tenths of a degree from $-5°$ to $+105°$ C. *Ch. F. Geissler and Son, Berlin.*

1050. Chemical Thermometer from $-10°$ to $+360°$ C.
Ch. F. Geissler and Son, Berlin.

1050a. Thermometer for Cooking, range to 600° F.
Harvey, Reynolds, and Co.

See Mrs. Buckton's book "Health in the House," page 153.

1051. Apparatus for determining the temperature of fusion. (Compare the adjoined description.) *Prof. Dr. Himly, Kiel.*

1052. Air Thermometer on the plan of Jolly. Compare Poggendorff's Annalen, Jubelband, 1873.
University of Munich (Prof. v. Jolly).

1052a. Original Air Thermometer, by Mr. Regnault.
College of France.

1053. Thermopile on the plan of Melloni of 64 bismuth antimony elements. *Wesselhöft, Halle.*

1054. Thermometer Stick for measuring temperatures at some depth. *Ludwig Meyer, Berlin.*

The instrument, adapted for depths down to 3 feet, is chiefly distinguished by the strength of its construction.

The bulb is in the nickel clamp, which latter stands by means of mercury in thermal connexion with the bulb. This mercury serves also as buffer to the thermometer bulb.

The horn clamp is replaceable by an iron screw, which facilitates the introduction of the thermometer into the ground.

Care is taken that only the clamp be thermo-conducting, not the whole tube.

1055. Milligrade Thermometer. The milligrade scale is one in which the interval of temperature between the freezing and boiling points of mercury is divided into one thousand degrees.

According to Dulong and Petit, mercury freezes at $-39 \cdot 44°$ C., and boils at $+360°$ C. For convenience, assuming that the freezing point is $-40°$ C., the interval is therefore 400 degrees C., thus it follows that $2\frac{1}{2}$ degrees milligrade are equal to 1 degree centigrade. Upon this scale the following results are obtained. Water freezes at 100° M. and boils at 350° M., the interval 250° being just one-fourth of the interval between the freezing and boiling points of mercury. Many other substances also show a curious relation in the interval between their freezing and boiling points to that of mercury, facts which are not obvious upon other thermometric scales.

The practical advantages of this system of graduation consist in the comparative smallness of the degrees, thus avoiding in many cases the necessity of the use of fractions to express the boiling point of substances; also that the zero point being so low the scale is a continuous one, all numbers under 100° M. representing temperatures below freezing water, but avoiding the necessity of the use of the minus sign, and at higher temperatures as 1,000° is approached, giving a clear idea that the heat is arriving at the extreme limit of thermometric registration.

In practically graduating this thermometer reference is not made to the freezing or boiling points of mercury, but the freezing point of water is marked as 100°, and the boiling point as 350°, and the scale carried upwards or downwards as required.

The conversion of centigrade degrees into milligrade degrees, or *vice versâ*, is extremely simple. A centigrade degree multiplied by $2\frac{1}{2}$, and 100

added, gives the milligrade degree, thus 40° C. multiplied by 2½ is 100, and 100 added gives 200, the degree on the milligrade scale. The correspondence between the Fahrenheit and the milligrade graduation is not so simple, as the interval on the Fahrenheit scale between the freezing and boiling points of water being 180° F., higher numbers are required to be used in the calculation. The following are the lowest common numbers for the scales:—25° milligrade, equal to 10° cent. and equal to 18° Fahr.

Thus it follows that the following rules can be applied to calculate one scale with the others—

To convert centigrade into milligrade degrees	-	$n \times 5 \div 2 + 100$.
To convert milligrade into centigrade degrees	-	$n - 100 \times 2 \div 5$.
To convert Fahrenheit into milligrade degrees	-	$n + 40 \times 25 \div 18$.
To convert milligrade into Fahrenheit degrees	-	$n \times 18 \div 25 - 40$.

John Williams, F.C.S.

1055a. Thermometer, with 19 differently graduated scales, traced on a silvered metal plate; the midst is taken in by the thermometer-tube and bulb. This instrument was made in 1754.

Professor Buys-Ballott, Utrecht.

1055b. Four Registering Thermometers.

E. Cetti and Co.

1055c. One Siemgan's Pyrometer. *E. Cetti and Co.*

1055d. Metallic Thermometer, indicator of two temperatures. *Francis Pizzorno, of Bologna (Italy).*

The movements of the index are in this instrument produced by the dilatation of two zinc blades which in the figure are seen edgewise. Along the graduated arc can be fixed two sliding pieces; if the index touches one of them, it closes an electric circuit and a ring bell placed in action. Two small pearls carried by a thread stretched between the extremities of the graduated arc, and which are displaced by the index in its movements, serve to indicate the maximum and minimum temperature.

1055e. Five Thermometers, various. *E. Cetti and Co.*

1067. Wedgwood's Pyrometer, consisting of pieces of clay, contracting according to the heat to which they are exposed. These are afterwards slid along the gradually diminishing and graduated groove in the brass plate, and so indicate the degree of heat to which they have been exposed. *Robert Garner, F.R.C.S.*

1068. Pyrometer, of iron and copper, for lecture illustration.

Yeates & Sons.

The above consists of a compound bar of iron and copper, bent into the form of U, one arm of which is firmly attached to the stand; the other arm is free, and carries a long index. If the compound U be immersed in a beaker of boiling water, the index will move over several degrees of the scale.

1069. Reflecting Pyrometer, for showing the difference of expansion of different metals. *Yeates & Sons.*

1070. Wedgwood's Pyrometer, invented in 1782.

Edinburgh Museum of Science and Art.

1075a. 'sGravesande's Ball and Ring Pyrometer, for showing expansion. *Harvey, Reynolds, and Co.*

1076. A Musschenbroek's Pyrometer from the first half of last century, with five different metal bars, and an autograph. Property of His Highness Prince Pless, Schloss Fürstenberg.
Committee of Breslau.

The apparatus has been constructed after the description and drawing given on p. 12 and Table XXX. of Musschenbroek's "Tentamina Experimen-" torum Naturalium Captorum in Academia del Cimento, Lugduni, 1731 " Pars. II." The orthography of the French, on an annexed slip of paper, is that of the beginning of the last century. The instrument, which is in capital condition, may therefore be considered as one of the oldest of its kind.

1078. Early Pyrometer (by Funiey).
Museum of Physical Apparatus, King's College.

1079. Daniell's Pyrometer, employed in researches by Professor Daniell.
Museum of Physical Apparatus, King's College.

1077. Bailey's Patent Civil Engineer's Pyrometer, for ascertaining the temperature of flues, &c., with sheath and box-wood handle to enable managers of works and others to carry it about with them for use when necessary. *W. H. Bailey & Co.*

1080. Bailey's Patent Flue Pyrometer, for testing the temperature of boiler flues, hot-air chambers, stoves, galvanisers, &c. *W. H. Bailey & Co.*

1080a. Hobson's Patent Hot Blast Pyrometer.
Joseph Casartelli, Manchester.

In this instrument the aim is to tone down the temperature of the blast by an admixture of a constant proportion of cold atmospheric air, so that the highest temperature likely to have to be recorded is brought within the range of a good mercurial thermometer. The hot blast is introduced in the form of a jet, which by suitable arrangement is made to induce a stream of atmospheric air; the mixed stream then passes on, and impinges on the bulb of the thermometer. The scale has been laid down by experiment, and the instrument gives the same reading as Siemens' copper ball pyrometer. It is found that pressure does not affect the result; and, as all the instruments are made exactly alike, the same result is invariably obtained. By the use of this instrument much time is saved, and the result is more reliable than with any other instrument in use.

1080b. Casartelli's Improved Pyrometer, for ascertaining the temperature of flues, stoves, &c.
Joseph Casartelli, Manchester.

This instrument consists of two different metals of different ratios of expansion, and any permanent set which may take place in the metals is compensated by the fact that the set will take place in opposite directions. The scale is laid down by experiment. It is so constructed that it is only necessary to expose one half of the stem to the action of the heat.

1081. Bailey's Patent Baker's Pyrometer, "Baker's Guide," for ascertaining the temperature of bakers' ovens, and enabling them to prevent the possibility of the bread becoming burnt, by keeping the oven at one uniform temperature.

W. H. Bailey & Co.

1082. Wood and Bailey's Patent Blast Furnace Pyrometer, for ascertaining the temperature of hot blasts.

W. H. Bailey & Co.

1082a. Photograph of M. Guyeau's Apparatus for determining the **Coefficients** of **Dilatation.**

M. Laurent, Paris.

1082b. Microgoniometer. An instrument for measuring the expansion of metals by heat. *Prof. Dr. F. Pfaff.*

III.—CALORIMETRY.

1057. Apparatus employed by Dr. Andrews in his experiments on the amount of heat disengaged in the combination of hydrogen and other combustible gases with oxygen. *Dr. Andrews, F.R.S.*

The gases contained in a cylindrical vessel of thin copper are exploded by the ignition of a fine platinum wire, and the heat is measured by the rise of temperature of the water in a calorimeter, capable of being rotated gently round its horizontal axis.

1058. Apparatus for determining the amount of heat produced in the combination of liquids and solids with oxygen.

Dr. Andrews, F.R.S.

1060. Thermometric Tube for determining the calorific capacities of different liquids. *Elie Wartmann, Geneva.*

A thermometric tube, being part of the contributor's apparatus for the determination of calorific capacities in liquids. A full description of the method is printed in the number for May 1870 of the "Archives des Sciences physiques et naturelles." An electric chronoscope, such as Sir Charles Wheatstone's, expresses in thousandth parts of a second the time necessary for the cooling between two constant temperatures of the same body (the thermometric tube) when immersed in equal volumes of different liquids, at the same initial degree of heat.

1061. Apparatus made by De la Rive and Marcet for measuring the specific heat of Gases. A small copper calorimeter, containing a very thin serpentine gold pipe.

Lucien de la Rive, Geneva.

1063. Drawing of an Apparatus for determining the calorific capacity of liquid substances.

Dr. Leopold Pfaundler, Professor of Physics at Innsbruck.

In a box protected against draught there are placed two calorimeters—one filled with water, the other with the liquid to be tested. An electric current is passed through the two spiral wires, both of equal power of resistance, which are inserted in the fluids.

Two paddles stir, and two thermometers measure, the temperature of the liquids.

The respective capacities of heat are calculated from the proportion of the increment of heat.

1063a. Original Apparatus of **M. Regnault** for ascertaining **Specific Heat** by observing **Refrigeration.**
College of France, Paris.

1064. The original Lavoisier Calorimeter. Fabre and Silbermann's original calorimeter for measuring the heat disengaged in combustion. *Conservatoire des Arts et Métiers, Paris.*

1064a. Original Vessel, by **Dulong,** for measuring **Specific Heat** by **Refrigeration.** *Polytechnic School, Paris.*

1064b. Original Apparatus, by **M. Regnault,** for ascertaining the **latent Heat** of **Steam** at different pressures.
College of France, Paris.

1065a. A Calorimeter. *M. Laurent, Paris.*

IV.—RADIATION.

1056. Hargreaves's Thermo-radiometer, for measuring losses of heat by radiation from walls of furnaces, sides of steam boilers, &c. *James Hargreaves.*

The silver-plated copper vessel is filled with water and enclosed in the case, the blackened face then being exposed for a given time (say five minutes) to the radiating surface, while a thermometer inserted in the neck of the vessel shows the elevation of temperature due to radiation. The heat is calculated as follows, either in calorics or British thermal units. $\frac{WS(T-t)}{a\,m} = x$. Where WS = weight and average specific heat of vessel and its contents; t, temperature of the same before exposure; T, temperature of the same after exposure; a, area of blackened face of vessel; and m, time of exposure, whence may be calculated the amount of fuel necessary to replace the heat lost by radiation.

1059. Diacalorimeter. To measure the resistance which liquids offer to the passage of heat. *Frederick Guthrie, F.R.S.*

Two conical platinum vessels, having their bases accurately plane, are supported so that their bases are parallel, horizontal, and nearly touching. The lower cone is fixed, and, being provided with an air-tight fitting vertical tube in which water stands at a known height, serves as an air thermometer and calorimeter. The upper cone can be adjusted by a micrometer screw at any

listance from the lower one. Through the upper cone a current of warm rater or steam is passed. Between the bases of the cones is introduced the iquid whose thermal resistance is to be measured.

1062. Apparatus used in researches on the **Absorption f Radiant Heat** by gases and vapours.

Professor Tyndall, F.R.S.

Phil. Trans., 1861.

1065. A pair of concave Reflectors of Prima German ilver, 500 mm. in diameter, on brass stands, with supports for carbon and tinder, for experiments on radiant heat.

Warmbrunn, Quilitz, and Co., Berlin.

1066. Melloni's Apparatus for investigating the laws of radiant heat. *H. Lloyd, Trinity College, Dublin.*

1072. Pouillet's Actinometer, for sidereal radiation.

Conservatoire des Arts et Métiers, Paris.

1072a. Actinometer, for measuring the intensity of Solar Radiation. *I. Louis Soret, Geneva.*

It is composed of a tube, of the diameter of about 35 millimetres, closed at one end, and blackened inside. The end, which can be opened by removing the stopper, is furnished with a diaphragm. The central tube is encircled with a concentric brass wrapper, which has to be filled up with pounded ice, or with snow. The apparatus is upheld by a horizontal axle upon a wooden support. This axle is formed of a tube which, on one side, lets out the rod of the thermometer (lacquered and blackened), and on the other may be adjusted to an air-exhausting pump. The apparatus is directed towards the sun ; the orientation is obtained by means of the exterior appendiculæ.

See Recherches sur l'intensité calorifique de la radiation solaire.—Comptes Rendus de l'Association Française pour l'Avancement des Sciences," 1st session, Bordeaux, p. 282.

1072b. Actinometer.

M. Desains, Member of the Institute, Paris.

1073. Pouillet's Pyrheliometer, for observations on solar at. *Conservatoire des Arts et Métiers, Paris.*

V.—ABSORPTION.

84. Ice-making Machine ; system of Raoul Pictet, & Co.
Raoul Pictet, & Co., Geneva. Geneva Association for constructing Scientific Instruments.

machine manufactures ice by means of anhydrous sulphurous acid. stance has the following advantages :—

s without action upon metals and fatty substances.

gives but slight pressures, never exceeding 4 atmospheres in a temperature of 30° centigrade.

3. It is free from all danger of ignition or explosion.
4. It is the least expensive volatile liquid.
This machine turns out 12 kilogrammes of ice per kilogramme of coal consumed.

1085. Apparatus for Freezing Water, constructed by Mr. Bieberich. Compare the adjoined instruction for use.
University of Munich (Prof. v. Jolly).

1086. ...all Ammonia Ice Machine.
Vaast and Littmann, Halle.

—

VI.—CONDUCTION.

1087. Model of Circular ... hot Copper Railway, for causing a metal ball to rotate by means of unequal expansion by heat.
George Gore, F.R.S.

Model in wood of circular railway, which when formed of copper heated to redness, and a thin cold ball of German-silver placed upon it, the ball rotates by the influence of unequal expansion produced by the heat. (*See* Philosophical Magazine, August 1859).

1088. Forbes' Iron Bar for **Thermal Conductivity,** with its crucible.
Professor Tait, Edinburgh.

1088a. Apparatus by **Peter von Musschenbroek,** a Dutch mathematician (born 1692, died 1761), to determine the relative values of the **Coefficients** of the **Expansion** of **Solid Bodies.**
Professor Dr. P. J. Rijke, Leyden.

1089. German Silver Bar, of same size, cast for same purpose.
Professor Tait, Edinburgh.

1090. M. Fizeau's Apparatus for measuring the **Coefficient** of **Dilatation.**
Conservatoire des Arts et Métiers, Paris.

1090a. Three Original Bars, by **Depretz,** on which were made the studies of the **Laws of Conductibility.**
The Faculty of Sciences, Paris.

1090b. Original Apparatus of **Regnault** for the **Dilatation of Gases.**
College of France, Paris.

1091. Depretz's Apparatus for showing the **Condu...** **of Heat** in metals with 9 thermometers.
Warmbrunn, Quilitz, and Co.,

1092. Ingenhous' Apparatus for demonstrating the **Conduction of Heat,** with nine rods of different metals.

Warmbrunn, Quilitz, and Co., Berlin.

1093. Apparatus intended to produce the **Curves** of **Thermic Conductibility** on the surface of bodies.

On the glass support are placed plates coated with grease, which may be coloured. The current of a battery is made to pass through the small platinum ball, which is at the end of wires of the same metal, and which are put into contact with the plate.

1093b. Four Boxes, containing plates subjected to the action of apparatus No. 1, and showing the isothermic curves produced by the fusion of the grease upon—

A. Bluish schist, from the valley of Sulvan, near Vernagaz.
B. Coal schist, from neighbourhood of Motivon, near the Col de Voza.
C. Another schist from the Col de Voza.
D. Septypite from Tholy (Vosges).
E. Clayey schist.
F. Hyaline quartz, with faces cut parallel with the axis.
G. Trooshte, silicate of zinc, with faces cut parallel with the axis.
H. Gneiss, fine grained, from the Val Anzasca, Monte Rosa.

M. Jannetaz, Paris.

VII.—POLARIZATION.

1095. Forbes' Mica Plates for the polarisation of heat by refraction. *University of Edinburgh.*

The mica is split into numerous thin films by careful application of heat, and fixed in the wooden tubes at the proper polarising angle.

VIII.—MISCELLANEOUS.

1096. Thermo-electric Diagram for teaching purposes. (Trans. Roy. Soc. Edin., 1872–3.) *Professor Tait, Edinburgh.*

1097. Apparatus employed by **Professors Stewart** and **Tait** for producing rapid **Rotation** in a **Vacuum.**

Professor Stewart, Manchester.

The driving shaft is of iron, and passes into the receiver through an iron tube containing mercury, which acts as a barometer.

This instrument was constructed and in part devised by R. Beckley, of the Kew Observatory, for an experiment conducted by B. Stewart and P. G. Tait.

Through the [illegible]

[illegible]

1097a. [illegible]
nault. [illegible]

1097b. [illegible]
the [illegible]

1098. [illegible]

1100. [illegible]

9.—MAGNETISM.

GROUND FLOOR, ROOM F.

RAL MAGNETS.

Magnet; the largest known. *See* lagnetismus," 1867, p. 107.
Teyler Foundation, Haarlem.

ure	- -	152 kilograms.
-	- -	114 "

et, mounted in brass case, with steel
Elliott Brothers.

stones (two), Russian, in perforated
Bennet Woodcroft, F.R.S.

stone and Spark Apparatus. This d by Faraday in his experiments on from which he first obtained the . Researches, vol. II.)
of King George III., King's College.

' ARTIFICIAL MAGNETS.

rtificial Magnets, lately forged by netised at Teyler's Museum.
Teyler Foundation, Haarlem.

17 kilogr.; greatest primitive force, 51·3 logr.
. 3,053. Weight, 1·52 kilogr.; greatest nanent force, 27·7 kilogr.
No. 3,003. Weight, 0·51 kilogr.; greatest r.; permanent force, 12·4 kilogr. No. 3,005. atest primitive force, 18·6 kilogr.; permanent

moveable side plates.
ol apparatus, to demonstrate the effect of mutual of the constitution of the keeper, on the distribution ight that can be suspended, and on the deflections

of produced by the magnet when open, and when more or less cl...

See the m oir of Prof. Van der Willigen, which will soon appear in the Archives du usée Teyler.

1109. ' **eat Artificial Magnet,** forged and magnetised in 1850 by I ssrs. Van Wetteren and Logemann, according to the directions .. Dr. Elias, whose property it is.

Teyler Foundation, Haarlem.

Newly magnetised a		
Weight -	- -	28 kilograms.
Primitive fc	- -	260 „
Permanent	- -	200 „

1109a. Large Artifi et made of thin Plates.

M. Jamin, Paris.

1110. Photograph of a e-shoe Magnet, made by Johann Dietrich, of Basle, in 1

Professor Hagenbach-Bischoff, Director, The Physical Institute in the Bernoullianum, Basle.

1111. Permanent Bar Magnets (pair of), in case.

James How & Co.

1112. Compound Horse-shoe Magnet. *James How & Co.*

1112a. Series of Permanent Magnets, bar form, in wooden cases for students. *Harvey, Reynolds, and Co.*

1113. A "Logemann's" Magnet, being a powerful battery of steel-plate magnets. *Frederick Guthrie, F.R.S.*

1113a. Magnets by M. Jamin. *M. Bréguet, Paris.*

III. ELECTRO-MAGNETS AND ELECTRO-MAGNETIC ENGINES.

1114. Saxton's Magneto-Electric Machine. Copy of the original machine made by Mr. Saxton, and exhibited by him before the third meeting of the British Association, held at Cambridge in the year 1833. *John O. N. Rutter, F.R.A.S.*

This machine was made specially for the contributor by Mr. Saxton, immediately after the meeting at Cambridge, and has been in his possession ever since. It is capable of producing sparks, shocks (through the tongue), and decomposes water It also reproduces the ordinary phenomena of electro magnetism.

The machine is described in Daniell's "Introduction to Chemical Philosop 1843, p. 555, sec. 878.

1115. Large Electro-Magnet, for showing magnetism and diamagnetism. *Elliott Brothers.*

1115a. Small Electro-Magnet by M. d'Obelliane, bearing thirty times its own weight. *Polytechnic School, Paris.*

1116. Three Electro-Magnets.
The Committee, Royal Museum, Peel Park, Salford.

One of which is a circular plate, 4½ inches diameter; another, a plate 4½ inches square; and the third, 4 inches, with one armature; the 4-inch magnet will sustain a load of 1,400 lbs. to 1,500 lbs. Made by the late R. Roberts, C.E., of Manchester.

1117. A Powerful Electro-Magnet.
The Committee, Royal Museum, Peel Park, Salford.

Of the horse-shoe form, with an elliptical section. Made by the late R. Roberts, C.E., of Manchester.

1118. Surface Electro-Magnet made in 1840. When fully excited the armature is retained with a force of upwards of a ton.
J. P. Joule, D.C.L., F.R.S., Broughton, Manchester.

1119. Electro-Magnet, on **Joule's Construction,** mounted so as to serve for supporting weights, or for experiments on Diamagnetism. *Made and exhibited by Dr. Stone.*

1120. Tubular Electro-Magnets.
John Faulkner, Manchester.

In this system iron cases are used, of such size and thickness as ensures the utilisation of the maximum force of magnetism.

The object is to accumulate and utilise all or a portion of the electric power, and thereby when desirable prevent the loss of force that takes place in electro-magnets usually employed in electrical appliances.

1121. Diagrams, illustrating the **Great Waste** of **Power in Electro-Magnets** as heretofore made, and the economy of tubular electro-magnets. *John Faulkner, Manchester.*

These diagrams are produced by scattering iron filings upon paper, prepared with paraffin, placed above ordinary electro-magnets and improved electro-magnets respectively.

1122. Objects illustrating the applications of tubular **Electro-Magnets.** *John Faulkner, Manchester.*

1. A. Electro-magnets; various.
2. B. Electric bells; various.
3. C. „ indicators; various.
4. D. „ semaphore actuators; various.
5. E. „ telegraph sounders; various.
6. „ „ „ key and sounder on one base.
7. „ „ „ „ „ separate.
8. „ „ „ sounder with movable cover.
9. „ „ „ „ with movable core.
10. „ „ „ „ with movable coil.
11. F. „ brass and iron separators.
12. G. „ pottery glaze iron extractors.

1123. Froment's Engine. An electro-magnetic machine depending upon the successive attraction by fixed electro-magnets of bars of soft iron fastened on a wheel and parallel to its axis.

Frederick Guthrie, F.R.S.

The successive magnetization and demagnetization of the magnets is effected by the action of cams on the axis of the wheel, which lift ivory rollers, and so displace springs to which they are fastened.

1124. Helmholtz's [illegible] magnetic Engine.

F. Rob. Voss, Berlin.

The advantage of this machi[illegible] is set in motion by a very small galvanic force; with two Bun[illegible] it will drive one of Professor Helmholtz's double-syrens or [illegible] trifugal commutators.

Professor Helmholtz [illegible] ct-arrangement to the commutator of the Siemens' bobbin [illegible] former ones in that it avoids great surfaces of friction, and so greater pow[illegible] nd speed is attained.

This is a new instrument, and [illegible] of an insulated plate covered with tinfoil, on which is screwed a met[illegible] inside this a glass ball runs about; one pole of an electric mac[illegible] ntact with the tinfoil, and the other pole with the metal ring; wh[illegible] cur[illegible] t passes the ball runs about.

1124a. Electro-magnetic Machine, with velocity regulator. Helmholtz.

Physical Institution of Berlin, Prof. Helmholtz.

The current which drives the electro-magnetic machine is interrupted by the centrifugal regulator whenever the velocity exceeds a certain limit, whereupon the driving force ceases. Using a current which is only a little stronger than what exactly suffices for the normal velocity, exceedingly constant velocities of rotation are obtained. (Described by M. Exner in the Litzungsberichte of the Vienna Academy, Math. Natura. section, Bd. LVIII, Abth. II, page 602.)

1125. Electro-magnetic Engine. *F. Stöhrer, Leipzig.*

1125a. Electric Motive Power, acting on a pump

M. Loiseau, junior, Paris.

1125b. Electric Motive Power, acting on a jet of water.

M. Loiseau, junior, Paris.

1125c. Electric Motive Power, acting upon a hammer.

M. Loiseau, junior, Paris.

1125d. Electric Lighting Apparatus.

M. Loiseau, junior, Paris.

1125e. Electric Telegraph. *M. Loiseau, junior, Paris.*

1125f. Electro-Magnetic Machine, invented by Wheatstone.

Wheatstone Collection of Physical Apparatus, College, London.

.125g. Electro-Magnetic Engine, patented by Thomas an, No. 14,190, A.D. 1852; and No. 2,243, A.D. 1854.

Lent from the Patent Office Museum by the Commissioners of Patents.

his engine is so constructed that when set in action several electronets are formed one after the other, and give successive impulses in the line or direction to an upright rod or bar, capable of being moved longinally to any desired extent.

.125h. Electro-Magnetic Machine, invented by Sir Charles eatstone.

Wheatstone Collection of Physical Apparatus, King's College, London.

.125i. Electro-Magnetic Machine, invented by Sir Charles eatstone.

Wheatstone Collection of Physical Apparatus, King's College, London.

APPARATUS FOR INVESTIGATIONS CONNECTED WITH PHENOMENA OF MAGNETISATION.

.126. Apparatus showing a remarkable property of gnetised Soft Iron Tubes.

Professor Dr. A. von Waltenhofen, Prague.

n a balance are suspended a tube and a solid cylinder, both of soft iron, cylinder being much heavier, and therefore counterbalanced by adding a s weight to the tube, or by filling it with shot. Both tube and cylinder introduced into an electro-magnetic helix, fixed upright beneath the nce at the bottom of the apparatus (as in the electro-magnetic balance of querel). The coils are joined so as to unite the poles of a Bunsen's cell, ny other voltaic cell of unimportant resistance.

n completing the circuit, a suction force is exerted on the tube and the nder, tending to draw them into the helices. The tube or cylinder will a appear the heavier, according as the electric current possesses less or re strength. This change can be performed at pleasure by means of a eatstone's rheostat, introduced in the path of the current.

he theory of this phenomenon is given in the Sitzungsberichte d. k. demie d. Wissenschaften. Juli Heft, 1870.

.126a. Apparatus by Mr. Th. Petroucheffsky, Professor at University of St. Petersburg, for **measuring** the distance of **Magnetic Poles** in straight magnets from their ends.

Imperial University of St. Petersburg.

. straight magnet is suspended horizontally at a point where one of the s is approximatively supposed to be. Another straight magnet, much ter than the first, is placed in the same horizontal plan, perpendicularly le suspended needle. A slow movement can be given to this second net along a divided rule, horizontal and parallel to the suspended needle.

The mutual (repulsive) action of the two magnets is greatest when the lengthening extension of the small magnet passes by the magnetic pole sought, provided that the suspended magnet remains perpendicular to the second magnet. To fulfil this condition an auxiliary magnet is used, which is placed on the other side of the suspended magnet, and which is to produce an equal, but contrary, effect to the second magnet. This method of finding out the poles has been described in Russian in the "Messenger of Mathematical Sciences" (Wiestin), and since, in Poggendorff's Annalen, Bd. 152, s. 42. It demands the use of three distinct apparatus: 1st. A "bifilaire" (double thread wire) appara[illegible] ding cylindrical magnets. 2nd. A measuring apparatus, having [illegible] net that can be moved along the apparatus, while keeping [illegible] o the direction of said movement. The apparatus has two [illegible] d is supplied with a microscope, two levels, and two sm[illegible] hort focus. These two apparatus are placed alongside, [illegible] nother, and, approximately, in the magnetic meridian. The [illegible] aratus consists of a divisioned rule placed perpendicularly to [illegible] agnet. Along this apparatus may be moved a small magnet, of which [illegible] nction has been explained above. The second of the apparatus enumer[illegible] s been constructed by Mr. Brauer, of St. Petersburg, from the designs of [illegible] essor Petroucheffsky.

1126b. Apparatus for so-called "**Normal**" **Magnetism,** by Mr. Th. Petroucheffsky, Professor of Physics at the University of St. Petersburg. *Imperial University of St. Petersburg.*

An iron cylinder for magnetising, placed symmetrically in a magnetising screw, may receive very different distributions of the free magnetism, according to the length of the screw, but the distribution does not depend on the strength of the current. The inventor has discovered that the distribution of the remanent magnetism, or rather the interpolar distance, stands always the same, independently of the length of the screw or the strength of the current. At a fixed length of the screw, the magnetic poles of the electro-magnet and the poles of the remanent magnetism coincide, so that the electro-magnet, placed horizontally and perpendicularly to the magnetic meridian before a sensitive magnetic needle, acts upon it in the fixed direction (say, the direction of the meridian itself) during the circulation of, and after the cessation of, the current; in the latter case, the poles of the remanent magnetism act. The poles are then almost at the ends of the magnetising spiral, the length of which is about 0·8 of the iron cylinder, independently of the length and diameter of the cylinder. This arrangement of the poles of the electro magnets is called "normal." The apparatus used in these researches are composed of two very distinct parts. The first apparatus contains two brass cylinders, surrounded with wire spirals; by turning one of these cylinders, the number of spirals can be lessened on the one, and increased on the other. Inside one of these cylinders the iron to be experimented upon is placed. This apparatus is set upon a table covered with marble plates moving in two directions, perpendicular to one another. The other apparatus is a needle, called "unipolar," suspended by means of a cocoon thread, with two microscopes.

1127. Ring of Elias for magnetising artificial magnets of large size. *Teyler Foundation,* [illegible]

A magnet of 28 kilogrammes weight has been recently magnetised [illegible] ring in Teyler's Museum.

Dr. Elias proposed more than 25 years ago his ring-coil for the [illegible] of artificial magnets of all dimensions, by an intense galvanic cu[illegible]

artificial magnet here exhibited has lately been re-magnetized, with a slight modification of his method by Prof. Van der Willigen in the Teyler Museum, by this ring with the current of forty Bunsen elements of the usual large size.

1128. Apparatus for showing to an audience the effects of the superficial tension of liquids (Tomlinson's Cohesion Figures); **Magnetic Curves** or the movement of liquid films, &c.
Prof. W. F. Barrett.

1129. One Bar of Metallic Nickel, 20 inches long and ½ inch diameter. *George Gore, F.R.S.*

1130. Three Plates of Metallic Nickel, 6 inches long and 1½ inch wide. *George Gore, F.R.S.*

1131. One Small Nickel Horseshoe, for making a Nickel Magnet. *George Gore, F.R.S.*

1132. One Plate of Metallic Cobalt, 6 inches long and 1½ inch wide. *George Gore, F.R.S.*

1135. Horse-Shoe Magnet of **Nickel,** used by Sir William Thomson in his experiment on the effect of magnetism on the thermo-electric quality of nickel. Result published in the Transactions of the Royal Society for the year 1856, Bakerian Lecture.
Edinburgh Museum of Science and Art.

1136. Apparatus for showing a series of molecular and magnetic changes in a red-hot iron bar; and designed also to show the influence of traction, compression, and torsion upon such changes. The latter experiments have not yet been made with it.
George Gore, F.R.S.

See Philosophical Magazine, Sept. 1870.

1136a. Apparatus for exhibiting molecular changes occurring during the heating and cooling of iron wire.
Prof. W. F. Barrett.

1136b. Apparatus designed by G. Gore, F.R.S., for exhibiting the effects of stress upon the magnetisation of iron.
Prof. W. F. Barrett.

1136c. Gore's Apparatus for exhibiting the torsion of an iron wire produced by axial and transverse magnetisation.
Prof. W. F. Barrett.

1136d. Class Apparatus for exhibiting the elongation of unstrained iron produced by magnetisation. *Prof. W. F. Barrett.*

1137. Coulomb's Torsion Balance for magnetic and electric observations. *Warmbrunn, Quilitz, and Co., Berlin.*

1138. Apparatus for the demonstration of Magnetic Friction, constructed by the late Mr. Kleemann in Halle.

Prof. Dr. Dove, Berlin.

V.—APPARATUS FOR INVESTIGATIONS CONNECTED WITH DIAMAGNETISM.

1139. Glass Tubes prepared by **Faraday** for testing the magnetic and diamagnetic character of **Gases.**

The Royal Institution of Great Britain.

The tubes containing the gas to be examined were suspended in the magnetic field of a powerful magnet, the result being either attraction or repulsion of the tubes as the gases they contained were either magnetic or diamagnetic.—Phil. Trans., 1850.

1140. Bars of Borate of Lead Glass, made and used by **Faraday,** for the action of magnets on polarized light.

The Royal Institution of Great Britain.

Phil. Trans., 1845.

1141. The Diamagnetic Box of Michael Faraday, containing spheres, cubes, and bars of diamagnetic metals; tubes of various liquids, bars of borate of lead, glass, various crystals, cradles, supports, &c., used by Faraday in his researches on diamagnetism. *Professor Tyndall, F.R.S.*

1142. Instrument used in researches on the **Polarity** of the **Diamagnetic Force.** *Professor Tyndall, F.R.S.*

Phil. Trans., 1856.

1143. Specimen of "Faraday's Heavy-glass."

George Gore, F.R.S.

1144. Electro-Magnet for Induction and Diamagnetic Experiments, made in 1850, of a broad plate of iron, so as to obtain the largest possible inductive power from the conducting wire. *James P. Joule, D.C.L., F.R.S.*

The coil is composed of a bundle of copper wires, and has a resistance about equal to that of a Daniell's cell, exposing a surface of one foot square.

1144a. A large diamagnetic Apparatus, with glass case, rods, &c. *Warmbrunn, Quilitz, & Co., Berlin.*

VI.—APPARATUS FOR THE OBSERVATION AND REGISTRATION OF THE TERRESTRIAL MAGNETIC ELEMENTS.

DIP AND INTENSITY INSTRUMENTS USED IN MAGNETIC SURVEYS ON SHORE AND AT SEA.

EXHIBITED BY THE ADMIRALTY—HYDROGRAPHIC DEPARTMENT.

1145. Dip Circle for observations at sea, fitted with special arrangements for finding the magnetic meridian. By Nairn and Blunt; date, 1772–1834.

This instrument may be considered as intermediate in construction between that made by Nairn for Captain Phipps, in his voyage towards the North Pole in 1773, and the Fox circle introduced by Mr. R. W. Fox in 1834, hereafter described.

It is suspended by an universal joint, from a wooden stand carrying one adjusting screw. The needle, 9 inches long, with steel axles, vibrates within a circle graduated to 20′, and the ends of the axis are fitted to work in the agate holes of two adjustable screws in the vertical bars supporting the circle, and otherwise strengthening the instrument. The sliding pointers on the graduated circle are intended to be adjusted to the mean position of the needle when the motion of the vessel causes it to vibrate on either side of the dip. The screw on the under side of the circle works the metal supports on which the needle is placed until adjusted in the agate holes. A thermometer graduated to 38° is placed inside the instrument.

The peculiar arrangement for ascertaining the magnetic meridian consists of a small compass gimballed at the end of a wooden arm. The other end of this arm has a brass fitting to fix on pins in the graduated circle on the top of he frame. The motion of the arm in azimuth causes the whole apparatus o move in the wooden stand until the Dip Circle is in the magnetic meridian, s indicated by the compass.

1146. Dip Circle and Intensity Apparatus. Fitted with rangements for ascertaining the magnetic meridian by three ethods. By Dollond; probable date, 1776–1834.

he Dip Circle is made after the pattern described by the Hon. Henry vendish in the Phil. Trans., vol. xlvi., in which the dipping needle rolls n horizontal agate planes, and a contrivance is applied for lifting it off on to the agates at pleasure. A milled headed screw works this lift, and djacent butterfly screw, an arrangement for causing the needle to vibrate. vertical circle is graduated to 20′; the outer circle of the base plate is graduated to every 45°.

e direction of the magnetic meridian may be ascertained by two methods than that usually adopted:—1. An edge bar horizontal needle fitted with ite cup may be placed on the steel point fixed to a balanced axis pro- for placing on the agates like the dipping needles. The coincidence of edle with the plane of the vertical circle shows the latter to be in the ic meridian. 2. The same edge-bar needle can be placed on a pivot in the centre of the graduated circle at the bottom of the travelling

three dipping needles, two are flat and one cylindrical and sharply- The axes are made of gun metal, and one of the flat needles is fitted ass cone on Mayer's principle.

In ... servations.—For this purpose the box which carries the dip c... with two apertures filled with glass, and a torsion circle on the t... two flat needles, one of gun-metal for eliminating tension, and the other for horizontal vibrations, have metal pins screwed into the centres by means of which they are attached to the stirrup suspended by silk fibres from the torsion circle. The vibrations are observed through the glass sides, and the magnetic meridian by the edge-bar horizontal needle before described.

This apparatus closely resembles that used by David Douglas on the north-west coast of America and the Sandwich Islands in 1829–34.

1147. Dip Circle. ... on; date, 1830–75.

In this circle the needles ... long, flat and pointed. They move on agate planes in the ... d circle, and observations are read off by means of lense... a moveable arm centred on one of the glass sides of the ...

The advantages of this ... are:—1. That both the needles can be read off for nearly ... dip. 2. Portability, from compactness of stowage in the box ... circle is fitted so as to be readily detached from the horizo...

An instrument of this ... was used by Major Estcourt during the survey of the river Euphrates in ...

1148. Dip and Int... rcle invented by R. W. Fox, F.R.S. By Mr. George, of Falmouth; date, 1834–75.

The principal object of this instrument is the observation of Dip and Intensity at sea, and when placed on a properly constructed gimballed table this can be accomplished, except in very bad weather.

The needles are flat, tapering from the axis to a point, and 6·9 inches long. The axles are finely pointed, and work in the jewelled holes fitted to the bracket and centre of a concentric disc in the back of the instrument, which also carries the bracket. The grooved wheel on the axis is used for carrying the hooks and deflecting weights in intensity observations. In the holes in the cross arms of the verniers at the back of the circle, the deflectors, N and S, are screwed for dip and intensity observations, and are set at any required angle by means of the graduated circle. Of the two large thumb screws in the back of the moveable disc, one works the bracket when mounting the needle and vice versâ; the other works the clamp. At other times they are used in conjunction for the purpose of moving the disc when altering the bearings of the needles in the jewels. The pointed projection between these screws, when rubbed by the ivory disc, opposes the effect of friction in the needle and jewels.

The needles are packed in metal cases with screw ends, and may thus be used as deflectors.

Instruments of this construction have been largely and successfully used in the various magnetic surveys made at sea in H.M.'s ships.

1149. Hansteen's Intensity Apparatus; date, 1819–50.

This form of intensity apparatus is that first adopted by M. Hansteen in his magnetic survey of Norway and the Baltic shores in 1819–24, and since largely used by various observers. The vibrating needle is cylindrical, pointed at the ends, 2·65 inches long and 0·15 inches in thickness. It is suspended from the moveable pulley at the end of the brass tube by a fibre of silk secured to a brass strap and loop in its centre. By means of the pulley the needle can be adjusted to the required height in the vibrating box.

The value of the observations depends on the permanency of the mag... condition of the needle.

1150. Portable Magnetic Dip Circle, 3½ in. needle, made for, and used by, the late Sir John Shuckburgh. The dividing is very fine, and believed to be Ramsden's. *G. J. Symons.*

General.

1176. Photograph of an Inclinatorium, by Daniel Bernoulli, completed by Johann Dietrich of Basle, in 1751.
Professor Hagenbach-Bischoff, Director, The Physical Institute in the Bernoullianum, Basle.

This instrument gained the Prize of the Academy of Paris in 1743.

1177. Dip Circle, for determining the magnetic inclination, adapted to needles of various lengths. (Barrow, London.)
H. Lloyd, Trinity College, Dublin.

1178. Theodolite Magnetometer, 9-inch circle, and collimator magnets. (Jones, London.)
H. Lloyd, Trinity College, Dublin.

1179. Dip Circle or inclination compass. *James How & Co.*

1180. Terrestrial Magnetism Magnetometer, new pattern, constructed to determine the magnetic moment of a magnet, and the direction and intensity of the magnetic force at a given place. *Elliott Brothers.*

The instrument consists of two distinct parts. For the observations of the deflection magnet, the copper box screwed to the centre of azimuth is used; underneath this passes, through the centre, a divided metal bar with a vernier carrying a magnet; at right angles to this bar is the observing telescope. The hollow vibration magnet, with a scale on glass at one end and a collimating lens at the other, is observed through another telescope. The latter magnet is suspended in the mahogany box above the copper box.

1184. Declinatorium for sea and land observations.
Carl Bamberg, Berlin.

The instrument is furnished with gimbals for use at sea, and may be fixed for observations on land. The magnetic system, which is provided with a speculum, is constructed for reversal, and oscillates upon a point; the adjustment is effected by means of a collimator telescope, and orientation from terrestrial and astronomical objects.

1185. Deviation Magnetometer, for determining the magnetic relations on iron vessels. *Carl Bamberg, Berlin.*

The deviation magnetometer enables determinations of deviation (declination and inclination) to be read off on points, and also determinations of horizontal and vertical intensity by oscillations and deviations. A small telescope serves for orientation by terrestrial and astronomical objects. The instrument may be mounted on the same stand as the compasses.

thermo-
F.R.S.

F.R.S.

F.R.S.

F.R.

Thermo-Electric Battery.

Thermo-Electric Pile.

. **Antinori's First Apparatus for Induction** **ction Sparks.** *Prof. Dove, Berlin.*

Thermo-pile (Noë's system), with 20 elements in arrangement, heated by gas. The electro-motive power) five Bunsen elements. *P. Dörffel, Berlin.*

e elements are arranged radially, so that the heating bars all iiddle point, where they can be heated by the single flame of a :ner. The cooling is done with metal plates which are rolled into orm, and serve at the same time as stands for the battery. The ive force is equal to 1 Bunsen or 20 Jacobi-Siemens units. This 'as also the next, 1300) is recommended for small experiments in , &c.

Thermo-electric Pile (Noë's system), heated by a p, with 20 smaller elements, and consequently of greater . The electro-motive power is equal to one Bunsen *P. Dörffel, Berlin.*

Thermo-electric Pile (Noë's system), heated by a p, with 10 smaller elements. Its electro-motive power is)·5 Bunsen element. *P. Dörffel, Berlin.*

l specially for medical use, in connexion with a small induction Should long action be desired it is well to place the battery with ressel with water, to avoid the great heating its small size involves, lt the action.

ı. **Thermo-Electric Generator (Clamond's** . Constructed either for electrotyping, plating, gilding, ıphy. A pile of 100 bars burning 4 feet per hour, will a ounce of copper per hour.

'hermo-Electric Generator Company (Clamond's Patent).

rmo-Electric Piles or Generators are constructed of elements, one ch is tinned iron, the other being an alloy of two parts of antimony zinc. The iron is cast into the alloy, and thus a perfect connexion The pairs thus formed are then laid side by side, and being cemented rm a ring or crown (the cement used is a mixture of asbestos and soda); one crown being complete another is laid above it, though rom it by the same cement, and so on, giving the pile a cylindrical e junctions are heated thus: Up the centre of the pile is placed a earthen tube and gas issuing from a Bunsen's jet burns at the perıeating an iron core red hot, which radiates its heat to the junctions s. thus the flame never impinges on the metals, and all oxidization, iated; the heated air passes over the top of the iron core, and rn, escapes by a pipe from the bottom of the pile. The elements wn are connected in series, but the terminals of every crown are to a wooden support and can be connected at will for high tension antity. As a standard of power the following may be used: —

ar pile consuming 4 feet of gas per hour has E.M.F. 5 volts., Int. ı.

nall tension bar pile, consuming 4 feet of gas per hour has E.M.F. nt. Res. 6 ohm.

: also made to be heated by coke or charcoal, and a battery having of 20 volts, and Int. Res. of 4 ohms burns 2 lbs. of coke per hour. is also used for heating the piles.

1301b. Thermo-Electric Pile of H

Consists of alternate layers of Palladium a
motive force equal to that of iron and copper.

d. INDUCTION COILS

1302. A Small Ruhmkorff's Induct

1303. Ruhmkorff's Coil. *Fr*

The current from a galvanic battery passing dov
excites a magnet, which by its attraction so
interrupt the current. The current being thus br
and the current is restored. The result is a very
of the current in the spiral or primary. Insid
soft iron, outside, many miles of fine insulate
secondary. Connected with the primary by wi
make and break, is a tin-foil condenser. This
when the primary is broken, and acts to augmen
primary is made. The interior magnetism acts in

1303a. First Induction Machine,
constructed under the direction of Ampère.
Co

1304. Six-inch Induction Coil, and Condenser, for obtaining spectra of m
spark.

When using the spark condenser the amount of
may be varied at pleasure, and the density of the s

1304a. Apps' Patent Induction C
17 in. in air, with a battery of five G
3 x 3 in. immersed.

1304b. Henry's Induction Coils.
Museum of King George III., K

1305. Large Induction Coil, with
give 1½-inch sparks. A cube of glass was

1305a. Electric Necessaire, containi
M

1306. Induction Apparatus for me
Keiser

1307. Induction Apparatus for me
Keiser

1308. Induction Apparatus for me
Keiser

1309. Spark Induction Machine, No. 1, with armature and Geissler's tubes. *Keiser and Schmidt, Berlin.*

1310. Spark Induction Machine, No. 2, with armature and Geissler's tubes. *Keiser and Schmidt, Berlin.*

1311. Spark Induction Machine, length of spark, six millimeters. *Keiser and Schmidt, Berlin.*

1312. Spark Induction Apparatus, length of spark, one centimeter. *Keiser and Schmidt, Berlin.*

1313. Induction Apparatus, length of spark, 4·5 centimeters. *Keiser and Schmidt, Berlin.*

1314. Induction Apparatus, length of spark, 8 centimeters *Keiser and Schmidt, Berlin.*

1315. Magnetic-induction Machine.
Baur and Haebe, Stuttgart.

1. This apparatus, containing several electro-magnets and a current regulator, is furnished with double coils of wire, and may be used to set in action electric apparatus of very various resistance and with very quick interruption of current, *e.g.*, Ruhmkorff coils. In general, any experiments may be made with it that are made with batteries of 1-6 Bunsen elements. It is suitable, for medical purposes, galvanocaustics, &c., and, if a part of the rotating electro-magnets be wound with fine wire, for production of a constant current up to 60 Meidinger elements.

e. Magneto-electric Machines.

1316. Ladd's Dynamo-Magneto-Electric Machine, with two wires on one armature. *William Ladd & Co.*

Invented March 1867. (*See* Proceedings of the Royal Society, No. 91, 1867.)

This was the first machine with two armatures, one being employed to excite the electro-magnets and the other to produce an electric current, which may be used for any purpose to which a battery is applicable.

1316a. Ladd's Dynamo-Magneto-Electric Machine, with two wires on one armature. This machine will heat 15 inches of platinum wire. *William Ladd & Co.*

1317. The first Magneto-Electric Machine, with circular magnets, 1866. *William Ladd & Co.*

1318. Magneto-Electric Machine, with circular magnets, larger form, 1867. *William Ladd & Co.*

1319. Magneto-Electric Machine (direct current).
James How & Co.

1320. Magneto-Electric Machine (Duchenne's form).
James How & Co.

1321. **Magneto-Electric Machine** (Clark's form). An early machine by Logemann, of Haarlem. *James How & Co.*

1322. **Electro-Magnetic Coil Machine,** for medical application. Primary and secondary currents. *James How & Co.*

1323. **Magneto-Electric Machine,** with alternate current for production of light. *La Société l'Alliance.*

An electro-magnetic machine, with four discs or 64 bobbins with alternate current for the production of ... machine, which requires a three horse power, revolves from 400 ... per minute and produces 200.

1324. **Magneto-** ... **chine,** workable by hand or steam. *La Société l'Alliance.*

An electro-magnetic machine for ... rpose of demonstration with eight bobbins with direct and alternate cu... workable by hand or steam.

1325. **Experimental M**... **to-Electric Machine,** the first constructed in which ele... ity and magnetism, rendered active by the expenditure of m... nical force, were made to act and re-act on one another in su... way as to greatly increase the development of their force. *S. Alfred Varley.*

This machine was the first of its class, and acted on what was a new principle at the date of its construction. The new principle consisted in making electricity and magnetism, rendered active by the expenditure of mechanical force, act and re-act on one another in such a way as to greatly increase the development of their forces. In this machine iron bobbins wrapped with insulated wire are revolved between the holes of very feeble magnets made of soft iron. The electricity (small in amount when the machine is first put in motion) which is developed in the insulated wire of the bobbins passes, by means of a commutator, through convolutions of insulated wire surrounding the soft iron magnets, and renders them more highly magnetic.

The magnetism of the soft iron magnets being thus increased, develops a corresponding increased quantity of electricity in the revolving bobbins, which re-acts on the soft iron magnets, rendering them still more highly magnetic.

The expenditure of mechanical force giving motion to the machine is greater as the magnetism and electricity developed increases the consumption of mechanical force having relation to the quantity of electricity rendered active.

1326. **Gramme's Magneto-Electric Machine,** for electrotyping. *H. Fontaine.*

1327. **Gramme's Magneto-Electric Machine,** for electric light. *H. Fontaine.*

1328. **Gramme's Magneto-Electric Machine,** for electric light of great power. *H. Fontaine.*

1329. **Gramme's Magneto-Electric Machine,** for demonstrating. *H. Fontaine.*

1330. **M. Le Roux's Electro-Magnetic Apparatus,** for showing the effect of magnetism on copper discs. *M. Ruhmkorff.*

1331. **Model of a Magneto-Electric Machine,** designed illustrate the advantage gained by the use of an electro-magnet place of the usual permanent magnet. *William Rayne*

This model of a magneto-electric machine is one that has been constructed for the purpose of showing the great increase of the electric current by the use of an electro-magnet in place of the permanent magnet, when such magnet is excited or charged by a galvanic cell; and this principle is applicable to all magneto-electric machines using soft iron magnets.

1332a. Portable Magneto-Electric Machine, with double coiled magnet. *Harvey, Reynolds, and Co.*

1336. Electro-Dynamic Light-producing Machines. *Siemens and Halske, Berlin.*

For setting these dynamo-electric machines in action a force of 6 horse-power is required for the larger and one of 3 for the smaller.

1336a. Various examples of Magneto-Electric Apparatus.

Electro-magnet, by Repmann.

Electro-magnet, by Jablokoff.

Electro-magnetic machine by Gramme, with a Jamin magnet of 0·08m.

Two secondary elements, by Planté.

Battery of 20 secondary elements, by Planté.

Battery of 20 secondary elements, by Planté.

Regulator of electric light, by Serrin, with glass globe.

Magneto-electric machine, by Gramme, for electric light of 150 burners.

Magneto-electric machine, by Gramme, with electro-magnet for laboratory.

Magneto-electric machine, by Gramme, with a Jamin magnet (small model).

Magneto-electric machine, by Gramme, with a Jamin magnet (large model with flier and pedal).

Exploder, with Jamin magnet (large model) with bobbin, cable, and key.

Exploder, with Jamin magnet (medium model).

Magnet, Jamin's, with plates 0·05m. in width.

M. Bréguet, Paris.

f. Other Modes of Producing Electricity or Electric Currents.

1337. Apparatus, designed to obtain electric currents by means of the combined action of gravity and motion. Preliminary experiments only have yet been made with it. *George Gore, F.R.S.*

1338. Apparatus for investigating electric currents produced by the friction of different metals. (Not yet completed.) *George Gore, F.R.S.*

13 ...lezenne's Circle. An instrument for developing electr... currents by the agency of terrestrial magnetism.

Elliott Brothers.

1342. Apparatus by which **Forbes** procured an **Induction Spark** from a **Natural Magnet.** *Trans. R. S. Edin.*, 1833.

University of Edinburgh.

II.—APPAR... ...LATING THE PLACE AND TIME A... ...THE EFFECTS OF AN ELECTRIC DISCH... ...R CONTINUOUS ELECTRIC ... ...DUCED.

1343. Six Specimens o... ...ular Binding Screws for making electrical connexions. *George Gore, F.R.S.*

1343a. Specimens of ... Electric Apparatus.

1. Copper wires, covered ...a-percha (1, 2, 25).
2. Copper wires, covered wi... ...a-percha and cotton (3).
3. Copper wires, covered with cotton (4, 5, 6, 9, 11, 12, 13, 14, 26).
4. Copper wires, covered with silk (7, 8, 10, 15 to 23, 27).
5. Elastic poires, with their cordons (24).
6. Wires covered with various metals, with statement of their resisting power. *Madame Ronis, Paris.*

1344. Double Terminal, by Captain R. G. Scott, R.E., to show the direction in which the spark tends to travel.

School of Military Engineering, Chatham.

1345. Single Plug Key, to close or break contact for long or short durations. *Elliott Brothers.*

1346. Fall-hammer, to obtain perfect equable closing of a circuit.

Prof. Engelmann, Physiological Laboratory and Ophthalmological School, Utrecht.

On a brass prismatic lever, movable round a horizontal axis, slides the bridge, a copper cover having underneath two amalgamated copper points. On depressing a spring the lever falls from a nearly vertical position, and plunges the bridge into two mercury vessels, movable on a horizontal sledge, and connected with the battery. A spring prevents the bridge from rebounding. Velocity of fall to be regulated by moving the bridge on the lever with corresponding displacement of the mercury vessels on the horizontal sledge.

By using the bridge as branch-closing, equable breaking (more correct diminishing) of a current may be obtained. The bridge being in the primary circuit of an induction apparatus, the breaking is every time to be effected at another place of the circuit, before lifting the bridge from the mercury, in order to prevent oxidation of the mercury by the spark.

The instrument can easily be managed with one hand.

1347. Firing Key, for torpedoes, &c. A simple contact key, th a movable piece of vulcanite, which can be brought between two platinum contacts to prevent fatal results by accidentally sing the circuit. *Elliott Brothers.*

1348. Apparatus for reversing the direction of an ectric Current. Used with an electro-magnetic torsion apratus. *George Gore, F.R.S.*

(*See* Philosophical Transactions of the Royal Society, Vol. 164, p. 529.)

1348a. A Current-reversing Electrode, with adjoints. *J. Teller, München.*

This gives a more convenient change of current than the commutators so r as electro-medical apparatus is concerned.

1349. Double Reversing Key, used for cable testing. *Elliott Brothers.*

1350. Thomson's Reversing Key, used in connexion with e electrometer, for facilitating the measurement of the electroatic capacity of a cable or condenser. *Elliott Brothers.*

1351. Lambert's Key, constructed for charging or discharging ibles and condensers. *Elliott Brothers.*

1352. Spottiswoode's Rapid Break, for use with Intensity oils. *Tisley and Spiller.*

By means of this break the discharge in vacuum tubes can be regulated, nd the motion of the stratifications diminished or rendered stationary, as quired.

1353. Contact Repeater, by Captain Armstrong, R.E., to peat electric contacts of exactly similar duration. *School of Military Engineering, Chatham.*

1354. Forms of discharge on making and closing an inducion current. *Prof. Donders, Utrecht.*

The trial with the noematachograph to have the instant of stimulation gistered on the chronoscopic line by the current itself, led to the discovery :

1. That the discharge can form a long series of sparks.
2. That the electricity disappears more slowly when the spring rests on metal, more rapidly when it rests on a plate of mica, than in the form of sparks making holes in the paper. (Compare Onderzoekingen gedaan in het phys. labor. Ser. 2, T. III. 1870; and Wiedemann, Die Lehre vom Galvanismus und Electromagnetismus, 2e Auflage, 1874, B. II., s. 360.)

1355. Drawings showing the patent system of lightning nductors applied to buildings. *J. W. Gray & Son.*

1356. Model of mid-section of a Ship, showing the patent stem of lightning conductors applied to vessels in Her ajesty's service, &c. *J. W. Gray & Son.*

1357. Indestructible Solid Copper Tape Lightning Conductors. Small and large sizes. *Sanderson & Proctor.*

This form of lightning conductor possesses the greatest conducting surface. Hitherto it has been made in short lengths riveted together; now it is made in any lengt without joints, thereby offering no resistance to the free passage of the electr : fluid.

1358. Copper Rope Lightning Conductors, improved. The smallest and largest sizes. *Sanderson & Proctor.*

1359. ... actor Apparatus. *Carl Wenzel Zenger, Prague.*

This apparatus consists of ... conductors arranged symmetrically, balls being used instead of ... ts. A plan shows its application to the I. R. Real School, and to ... l Theatre at Prague.

1360. Top of ... nductor. The lower part is made of gun metal, the upper ... pper, and the extreme point of gold or silver. Const ... rding to the instructions of Professor Ed. Hagenbac ... in Basle. *G. Linder, Basle.*

The electricity escapes easily ... good conductors from points and edges; the point does not oxidise ... the atmosphere, and being a good conductor is not liable to be melted by electricity.

1361. Needle of Lightning Conductor, brass gilt. *Geneva Association for Constructing Scientific Instruments.*

1362. Lightning Conductors (various kinds). *John Faulkner, Manchester.*

Two photographs of expedients for applying lightning conductors to high spires and factory chimneys, and for the repair of high spires and chimneys.

1363. Models of Lightning-Conductors of the latest construction. *Mittelstrass Brothers, Magdeburg.*

1364. Apparatus serving **for the separation and collection of induced currents,** constructed by Dr. Th. Tasché, manufactured by Staudinger & Co., in Giessen. *Dr. Tasché, Giessen.*

1364a. Current Analyser, with glass axis, made by Jung, of Giessen. *Physical Institute (Univ. of Giessen), Dr. Buff.*

The "current analyser" could be occasionally used for experimental research in voltaic induction, to separate the two induced currents, and to study the proportion of their intensities or electro-motive forces. See Poggendorff's Annalen, Vol. 127, p. 57.

1365. Binding Screws for **Galvanic Work.** *M. Th. Edelm... Munich.*

1366. Current-key for **Beetz's Compensatio...** *M. Th. Edelmann*

III.—APPARATUS FOR ACCUMULATING ELECTRICITY.

1367. Leyden Jar of five and a half square feet coated surface. *Teyler Foundation, Haarlem.*

This jar is one of the 100 jars arranged in four cases, by which Van Marum constructed a battery of 550 square feet coated surface. The coatings of tinfoil have been renewed recently; but all is restored in the form in which it was used by Van Marum.

See Van Marum, "Machine Électrique," II., p. 195.

1368. Leyden Battery of 15 jars.

Teyler Foundation, Haarlem.

This battery is one of 16 used by Van Marum for his famous experiments, giving a total coated surface of 225 square feet.

The coatings of tinfoil have been renewed recently; the bottom of tea-lead in the case is also restored; and the outer coating of the case bottom, which Van Marum also made of tea-lead, has been replaced by zinc.

See Van Marum "Machine Électrique," I. p. 155, and II. p. 3.

1369. A Battery of 10 one-gallon Leyden Jars.

Frederick Guthrie, F.R.S.

This battery stands in a mahogany frame. The jars stand upon perforated zinc. There is an arrangement for drying them by a current of hot air. The spark from this battery deflagrates a platinum wire a foot long.

1369a. A series of Leyden Jars, with connectors, hard cement. Cover 10 pieces from 90 to 100mm. high.

Warmbrunn, Quilitz, & Co., Berlin.

1369b. Battery of Leyden Jars, consisting of six jars 312mm. high, in mahogany case. *Warmbrunn, Quilitz, & Co., Berlin.*

1369c. A Cylinder, on insulating support.

Warmbrunn, Quilitz, & Co., Berlin.

1369d. A Cylinder, with elder-pith balls.

Warmbrunn, Quilitz, & Co., Berlin.

1369e. Sphere, on insulating support, with two movable hemispheres on shellac rods. *Warmbrunn, Quilitz, & Co., Berlin.*

1369f. Large dissected Leyden Jar.

Warmbrunn, Quilitz, & Co., Berlin.

1370. Spiral Leyden Jar. *Frederick Guthrie, F.R.S.*

Two sheets of ebonite, alternating with two sheets of tinfoil, are rolled up together. The central knob is connected with the inner edge of the arc of the foils; the brass girdle is connected with the other sheet. A Leyden jar is thus formed which is compact with a large surface.

1371. Mica-plates for isolating electrical apparatus.

Max. Raphael, Breslau.

S 2

and a cylindrical tube, each of which holds one of the two equally long wires as electrodes. The tension of electricity with which passage occurs is much greater when the wire serves as cathode in the narrow part than when it is anode. This may be shown if a spark micrometer be introduced in the induction current near the tube, and for each of the two directions the interval of the balls be determined with which the current takes the path through the tube. If the wire in the wide reservoir, being cathode, be placed in conductive connexion with the third aluminium wire, which is in the beginning of the cylindrical tube, the current can no longer pass over in the latter to the former. This, therefore, loses its neg... ...d only with the greater tension, such as occurs with the other ...he passage of electricity effected. (Cf. Pogg. Ann., Bd. 136, p. ...

The aluminium wire, whi... ...eathed with glass, with exception of the last cross sectio... ...of the opening induction-current. The straight dischar... ...ction, when the tubes are brought over and between the ... ...agnet, behaves like a flexible conductor which is fixed at one end... ...other freely movable, and follows the Laplace-Biot laws. (Cf. Po... ...l. 136, p. 213.)

1377e. Three Tubes o... ...with rarefied air to show the magnetic behaviour of the ne... ...low light.

Prof. Hittorf, Münster.

5. The negative electric discharge which, with great rarefaction, occurs at a cathode with small surface, raises the conducting particles of gas to a very high temperature. When strong induction currents are used, these, notwithstanding their small mass, are capable of raising the surface of badly-conducting solid bodies with which they come into contact to a red heat. This heating, which the negative discharge gives in much greater degree than the positive, produces with the best light-givers, like sulphide of calcium, a light of dazzling intensity.

1377f. Three Glass Tubes of Rarefied Air and Sulphide of Calcium, to show the phosphorescence of the negative electric light.

Prof. Hittorf, Münster.

1378. Gassiot's Star. *Frederick Guthrie, F.R.S.*

This exhibits (1) the varieties of the electric discharge through various rarefied gases in tubes of different shapes, and (2) by being rotated shows by the retention of images the intermittent nature of the discharge.

1379. Block Specimen of Glass, 2½ inches high, penetrated vertically by an electric discharge. (By Ruhmkorff, of Paris.)

George Gore, F.R.S.

1380. Effect of Lightning. Portion of a half-sovereign and a fragment of sheet iron fused together by a discharge of lightning in the colony of Natal. This and other coins were in a tin box, of which this fragment alone remained.

Robert James M...

1381. Metals fused into Glass by Lightning.

Alfred B.

Frame No. 1 consists of strips of zinc, tin, and lead, fused into glass ... actual flash of lightning, collected by means of "exploring wires" str...

over the grounds of the late Andrew Crosse, and converged into his electrical room, as shown in the stereograph. It was here accumulated in the great Leyden battery of 50 jars, and passed thence by dischargers through the metals, which were burnt into the glass on which the strips were laid.

Frame No. 2 contains composite strips of copper and iron, gold and tin, and gold, silver, and copper, fused in like manner.

A photograph of the Leyden battery, with which the experiments were performed, accompanies the frames.

1382. "Thunder House," or model to illustrate the identity of lightning and electricity, and the use of lightning conductors in protecting buildings—said to be the first model of the kind, and to have been made by Dr. Priestley with his own hands.

Conrad Wm. Cooke, M. Inst. C.E.

1383. Old Electric Egg (beginning of last century).

Prince Plesh.

The great age of the instrument appears both from tradition and from the style of the wooden frame and the nature of the brass work. It is certainly one of the oldest instruments of the kind.

1384. Apparatus employed by Sir Charles Wheatstone to determine the **Velocity** and **Duration** of the **Electric Discharge.**

Rotating mirror. Spark disc. Early rotating disc with balls and sliding rod.

Museum of Natural Philosophy, King's College.

791. Rotating Tube Holder, a contrivance for containing a number of Pflücker's tubes, and obtaining their spectra successively without loss of time. *John Browning.*

792. Rotating Metal Holder, suggested by Mr. Lockyer, for holding specimens of all the principal metals, and obtaining their spectra successively, or for the purposes of comparison.

John Browning.

1385. Riess' Spark Micrometer. *F. Rob. Voss, Berlin.*

This is well suited for school use, as it is not very dear, and its action is, in proportion, as good as that of larger machines.

There are new arrangements in the Leyden jar for raising or turning the needle without shaking the entire instrument (a thing to be avoided).

1386. Apparatus for testing with Lightning Conductors. *M. Th. Edelmann, Munich.*

1387. Electrograph, apparatus for the production of electric sand-figures, constructed, from the plan of the exhibitor, by M. Th. Edelmann. *Prof. W. von Bezold, Munich.*

This serves for study of the nature of the electric discharge in simple or branched circuits, with the aid of sand figures. The figures exhibited have partly been produced with this apparatus, partly under the air pump, and by means of a caoutchouc solution transferred from the ebonite plate to black

silk-paper. They are accordingly not copies, but true originals, produced by the discharge.

1388. Framed Table, with electric dust figures.
Prof. W. von Bezold, Munich.

VI.—APPARATUS FOR PRODUCING AND OBSERVING EFFECTS OF CONTINUOUS ELECTRIC CURRENTS.

a. Heating and Luminous Effects.

1389. Diagram showing the **Amounts** of the **Electro-motive Force,** and the **Peltier** and **Thomson Effects** in a **Thermo-electric Circuit** of **Iron-Copper,** both junctions being at temperatures under the neutral point. For teaching purposes.
Professor Tait, Edinburgh.

1390. Peltier's Apparatus, for studying the effect of heat in metals subjected to the action of electricity.
Conservatoire des Arts et Métiers, Paris.

b. Chemical Effects.

1391. Apparatus for the polar **Decomposition** of **Water** by means of atmospheric electricity or the currents of the ordinary electrical machine. The gases are collected in fine thermometer tubes, by which means their absorption by the electrolyte is avoided.
Dr. Andrews, F.R.S.

1391a. Apparatus for Decomposition of Water, peculiar construction, with graduated tubes for the separated gases and for the detonating gas. *Warmbrunn, Quilitz, & Co., Berlin.*

1392. Bottle, containing fragments of pure **Electro-deposited Metallic Antimony.** *George Gore, F.R.S.*

(*See* Philosophical Transactions of the Royal Society, 1857, 1858, and 1862.)

1393. Two Specimens of **Electro-deposited Antimony;** one of the explosive, and one of the pure variety.
George Gore, F.R.S.

1394. A Rare Specimen of pure Carbon, deposited by means of an electric current upon a rod of platinum.
George Gore, F.R.S.

c. Electric Diffusion and Change of Surface-tension.

1395. Apparatus for producing Vibrations and Sounds, and an intermittent electric current by means of the electrolysis of

a solution of cyanide of potassium and mercury with electrodes of mercury. *George Gore, F.R.S.*

The effects are produced by the alternate rapid formation and destruction of films upon the positive electrodes. (*See* Proceedings of the Royal Society, Vol. 12, p. 217.)

1395a. Electro Capillary Force Machine, after Lippmann. *R. Jung, Heidelberg.*

To set this machine in action, the two wide glass vessels are first filled to a height of 1 to 3 cm. with mercury, placed in position in the glass trough, and then filled two thirds with pure dilute sulphuric acid. Then the two bundles of thin glass tubes are pushed repeatedly down into the mercury, so that the air is driven out, and the tubes and their intervals are quite filled with mercury and acid. Then the bundles are fixed by screwing to their frames, so as to be about half immersed in the mercury, and to stand in equilibrium in the middle of their respective vessels. If the little cups of the key be now filled with mercury, and the crank which works it so placed that the current is reversed a little before the opposite crank comes to its dead point, the machine (having been connected with the poles of a Daniel) will commence working, and may make as many as 100 revolutions in a minute. A Meidinger element keeps the machine in action for months.

1395b. Apparatus for electric osmose. *Prof. Hittorf, Münster.*

In each of the three divisions formed in the glass cylinder by the clay plates the electric endosmose (when the vessel is quite filled with the solution of an electrolyte) is produced or prevented according as, on passage of the current, the three openings are free or are closed. With the arrangement it is proved that the transference of the ions is quite independent of the electric endosmose. (Pogg. Ann., Bd. 96.)

d. Effects due to the Force between Currents and Magnets.

1396. Apparatus for showing the Rotation of a Bar-magnet on its axis by the passage through it of an electric current. *George Gore, F.R.S.*

(*See* Proceedings of the Royal Society, Vol. 24, p. 121.)

1397. Apparatus for showing the Rotation of a Copper Wire upon its axis between the poles of two magnets by passing through it an electric current. *George Gore, F.R.S.*

(*See* Proceedings of the Royal Society, Vol. 24, p. 121.)

e. Effects due to the Force between Currents and Currents.

1398. Apparatus for demonstrating the Laws of Ampère. *Geneva Association for Constructing Scientific Instruments.*

The mode of suspension used in this apparatus allows the conductor to make a complete revolution.

The current passes from the movable conductor into an annular cup, concentric with the axis of the motion and filled with a conducting liquid.

All the conductors are made of aluminium so as to lessen their weight as much as possible.

The apparatus may be used for a great number of experiments; it is specially adapted for the following demonstrations:—

1. Parallel currents in the same direction attract one another, and those in contrary directions repel one another.
2. Angular currents in the same direction attract one another, and those in contrary directions repel one another.
3. The attraction and repulsion of the same current are equal.
4. A sinuous current acts like a rectilinear current of the same general direction and having the same extremities.
5. A closed current takes a direction perpendicular to the magnetic meridian.
6. A solenoid has the essential properties of a magnet.
7. The elements of the same current repel one another.

The mutual action of magnets and currents is demonstrated by means of the same apparatus, by replacing one of the currents by one or more magnets.

1398a. General Table, by Ampère, with apparatus used by him in the discovery of the action of currents.

College of France, Paris.

1399. Apparatus for demonstrating the action of Metallic Discs in movement upon a metallic wire used as a voltaic conductor. *Professor Daniel Colladon, Geneva.*

Experiment performed on 4th September 1826, in presence of the Paris Academy of Sciences, by Messrs. Ampère and Colladon.

Bulletin de Sciences Mathématiques, by De Férussac, vol. 6, p. 212.

1400. Model of a Circular Railway, for showing the rotation of a metal ball upon it by the passage of an electric current. *George Gore, F.R.S.*

(*See* Philosophical Magazine, Feb. 1859.)

1401. Electro-Spherical Motive Power, with double motion. *G. Trouvé, Paris.*

VII.—APPARATUS FOR REGULATING THE STRENGTH OF ELECTRIC CURRENTS.

1402. Wheatstone's Rheostat, or changeable resistance, for quickly adding or subtracting a low resistance.

Elliott Brothers.

1403. Voltastat and Voltameter combined.

Frederick Guthrie, F.R.S.

Air-tight through the stopper of a cylindrical vessel containing dilute sulphuric acid pap. (1.) Two platinum wires coated with glass. (2.) A long and wide tube open at both ends, the lower end reaching to the bottom of the cylinder. (3.) A tube opening freely beneath the stopper and above by a very fine capillary opening. The platinum wires are enlarged into platinum plates, which are triangles with their apices downwards, and further apart

their bases. Increase in the current passing by means of the wires be-
ı the electrodes causes the liquid to rise higher in the manometer tube,
ılso by laying bare the electrodes, increases the resistance.

104. The Voltaic Compensator, an apparatus for main-
ng constant the intensity of the electric current derived from
sort of voltaic battery.

Elie Wartmann, Professor of Natural Philosophy in the University of Geneva.

ıe voltaic compensator is an apparatus which keeps the intensity of the
nt from any voltaic battery constant. A full description is printed in
ıumber for January 1858 of the "Archives des Sciences physiques et
elles." In addition to the principal current, which, if constant, would
ıe work required, there is an auxiliary one, the strength of which is
down by inserting an additional resistance. This resistance diminishes
the weakening of the principal current, and the consequent increase of
ıxiliary current compensates that weakening.

104a. Regulator, by Foucault. *M. J. Duboscq, Paris.*

105. Apparatus to make the **Electric Light,** derived
a **Voltaic Battery,** constant in its position and intensity.

Elie Wartmann, Professor of Natural Philosophy in the University of Geneva.

ı apparatus called a fixator of electric light, used in the years 1856 and
for lighting the harbour of Geneva. A full description is to be found
ıe number for December 1857 of the "Archives des Sciences physiques
turelles." By means of an electro-magnet and of gravity, two points
rbon are placed and kept at such a distance that the light produced by
urrent of an electric battery may be as bright as possible.

406. Regulator of Electric Currents, after the plan of
Mascart. *M. Redier.*

407. Regulator for the Electric Light. *M. Carré.*

408. Artificial Charcoal Sticks for the Electric Light. *M. Carré.*

409. Electric Lamps. These lamps are automatic in their
on, in them the carbon points are caused to approach or recede
n each other as required, without the aid of clockwork.

Siemens and Halske, Berlin.

I.—APPARATUS FOR DETECTING AND MEASURING DIFFERENCES OF ELECTRIC POTENTIAL AND CURRENTS OF ELECTRICITY.

a. Electroscopes and Electrometers.

410. Two Repulsion Electrometers constructed and
by Van Marum. *Teyler Foundation, Haarlem.*

166
Mors
schools

For t
This ap
low pric
every sc

166

In th
wires) is
strand o
molten t
into a s
percha,
wrapped
round th

167

Two d
powerful
indicatio

167
positiv

167
of fire
Cambr

This
&c., gas
vatories,
The i
There
the carg
pair of e
other ba
fixed an
The p
and bell
portion
tance so
when in
Thus
compart
or broke
from the
mentione
the instr
become subject to a

). Cooke and Wheatstone's A B C Instrument,
Reid Brothers, London.

:apement wheel on the axle of which the pointer is fixed is con-
' electro-magnets.
mmunicator is outside, and concentric with the indicator dial, and
f a cog-wheel working into two smaller wheels. The cog-wheel is
y a handle, and the battery contacts are made by small wooden
inlaid with metal fixed on the smaller wheels.
heelwork is driven by a mainspring.

). Nott's Step by Step Pointer Telegraph, 1846.
Reid Brothers, London.

-magnets act on a ratchet-wheel by means of clicks attached to their
s. On the axle of the ratchet-wheel the pointer is fixed; the latter is
rward through a space equal to the distance between two letters for
ing and breaking of the battery contact. A simple tapper or pedal
ed for sending the currents, and the pointer is allowed to rest for a
rval when it is opposite to the letter desired to be indicated. The
at is furnished with an alarum, the bell being struck by a hammer
to the armature of an electro-magnet provided for the purpose.

a. Double Indexed Telegraphic Post, with alphabe-
ceptor, indicator, and printer at will; manipulator (Cham-
ystem) in every direction. *M. Deschiens, Paris.*

hole of this apparatus is enclosed in a case for protection.

1. Pocket Telegraph Instrument and Writing atus, arranged for reversing.
Siemens and Halske, Berlin.

2. Magnetic Telegraphic Apparatus, with printer.
Siemens and Halske, Berlin.

3. Pocket Printing Apparatus, with feeder.
Siemens and Halske, Berlin.

4. Quick Composer, with printer.
Siemens and Halske, Berlin.

4a. Printing Telegraph, invented by M. H. Jacobi,
ician, in the year 1850. Two uniform apparatus for two
s.
Physical Science Cabinet of the Imperial Academy of Sciences at St. Petersburg.

5. Apparatus for making contact to show the height of
with float, rod-chain, counterpoise, and water tube.
C. & E. Fein, Stuttgart.

s self-acting, and registers at any distance off the water-level in a
:, &c.

X 2

This coil, in which by means of a single medium sized element of constant power, induced currents of considerable force may be produced, was frequently used by A. de la Rive in his researches.

See "Archives de l'Electricité" by de la Rive, 1841, Vol. 1, p. 280.

1744. "Bréguet" Thermometer, used and referred to by **A. de la Rive** in his works upon the causes of voltaic electricity, and upon the properties of magneto-electric currents.

De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

1745. Photog[illegible]ial Collection of Instruments used by Volta.

Royal Lombardia[illegible]ution of Science and Letters.

1st Plate:

1. Electrophorus, with mastic case, designed by Volta.
2. Condensing electrometer, the same which Volta made use of to demonstrate metallic electricity.
3. Columnar pocket pile, adopted by Volta to demonstrate his theory at the Institute of Paris, Bonaparte being present.
4. Letter of Volta in the origi[illegible]
5. Lamp for hydrogen gas, wh[illegible] ignited by the electrophorus. It has the form of those lamps which Volta diffused so much in Germany.
6. Apparatus which served at the first researches of Volta, being available for collecting and rendering appreciable the smallest quantities of electricity.

2nd Plate:

The same instruments on former scales.

3rd Plate:

Fac-simile of part of a letter of Alexander Volta to Professor Bartletti, dated Como, 15th April 1777.

1746. Galvanic Battery, by **A. de la Rive.** The **Grove Battery** modified, with nitric acid on the exterior. **Constructed** by the Geneva Association for constructing Scientific **Instruments.**

De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

The nitric acid is placed in a large glass phial, whence it is unnecessary to let it out. It is of sufficient quantity to serve for a long time without being changed.

The diaphragm containing the acidulated water and the zinc closes perfectly the orifice of the phial; when the battery is taken to pieces, this diaphragm is replaced by a ground stopper. By this arrangement, the disengagement of nitrous vapour is avoided. This battery may thus safely remain in the experimenting room, close to the apparatus, and is especially fit for working a Ruhmkorff coil. Two elements suffice for a medium sized coil. De la Rive constantly used this apparatus for his researches upon induced currents, and always left it in his laboratory.

1747. Floats, constructed by **Gaspard de la Rive.**

De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

Apparatus intended for the demonstration, in a simple manner, of the "Laws of Ampère" upon the reciprocal action of currents. The conductor can be adapted directly upon a small floating battery.

1748. Apparatus, by **A. de la Rive,** for the derivation and the relative measurement of **Induced Currents.** Used by himself in his studies upon rarefied gases.

De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

Used for diverting into a galvanometer a very small portion of a current of induction. This current passes through a glass trough filled with distilled water, in which are dipped two platinum wires, joined to the galvanometer. The current which was passing through the thin liquid thread placed between the wires is partially diverted into the galvanometer, which thus measures a quantity proportioned to the total intensity of the induced current that may go through the trough.

The deviation of the needle of the galvanometer increases proportionally with the distance between the wires.

This apparatus was often used by De la Rive in his researches respecting the passage of the induced current through rarefied gases.

1748a. Apparatus used by **De la Rive and Sarasin** to demonstrate that **Rarefied Gases,** crossed by inductive discharge, become condensed under the action of magnetism.

De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

The inductive current passing through the tube with two compartments, one of which is placed between the two poles of a powerful electro-magnet, the glass cock is rapidly turned round, thus interrupting the current, and separating the two compartments. These are afterwards brought into communication with a very sensitive manometer, and it is then found that the pressure is a little greater in the one which has been between the two poles of the magnet, and which will also contain the negative electrode.

(See Archives des Sciences Physiques et Naturelles; new period, vol. 41, p. 5; and Philosophical Magazine, 4th series, vol. 42, p. 211.)

1748b. Apparatus used by **A. De la Rive** in his Studies upon the **Magnetic Rotatory Polarisation** of **Liquids.** (Made by the Geneva Association for Constructing Scientific Instruments.)

De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

1. The Nicol polariser.
2. Tube for holding liquids, with double wrapper for the heating required for studying the influence of the atmosphere upon the phenomenon.
3. The Analyser, with graduated circle and special register, invented by M. Thury. This consists of two tangent discs in ivory, the one supported by the analysing Nicol, the other by the pinion that helps to turn it, and of a horizontal ruler. A pencil mark made by this ruler on both discs shows the position of the Analyser. Instead of having to read each observation separately, which is inconvenient in experiments made in the dark, the corresponding mark to every observation is simply noted, and afterwards reckoned altogether. (*See* Archives des Sciences Physiques et Naturelles, vol. 38, p. 209.)

1749. Apparatus designed by **Auguste de la Rive,** for the demonstration of the **Electric Theory** of the **Aurora Borealis.**

1 **our-inch Achromatic Telescope,** on altazimuth stand, a quick and slow motions, in altitude and azimuth.

John Browning.

1766. **strument for Easy Determination of Time by Equal Al tudes of Different Stars.**

Colonel Zinger, Pulkowa.

This instru ent is constructed for easy application of the method developed lately by Col nation of time by equal altitudes of different stars Astronomischen Gesellschaft, 1875). The principal n of level to telescope in going over from a star i ent by having found its vertical axis. The divided circles serve e telescope. For using only bright and well determined or 4) magnitude, 9 minutes of time will be in the average e with the accuracy of 0·1ˢ. The eye-piece of the telescope is prov vith a micrometer, to enable the observer to get with the same in by approximately equal altitudes of two stars near the meridian, exa nation of latitude.

c. Transit Circles and Quadrants.

1767. **Meridian Circle,** with object glass of 6″ aperture and 6′ focal length. Circle of 2′ diameter under construction for the Observatory of Strassburg. (Photograph.)

A. Repsold and Sons, Hamburg.

(5.) In this instrument the microscopes are attached to the heads of the cast-iron columns, which also bear the bed-plates. One of the pivots carries an objective (2″ aperture), and the other a plate with a bored hole; this arrangement serves, at the suggestion of Prof. Winnecke, as a collimator for controlling the position of the axis. Perfectly central illumination of the field of view is effected by a small mirror at the back of the objective. The heads of the objective and eye-piece can be changed in the heads of the telescope, and there is an arrangement for Nadir observations, also for reflex star observations with a Nadir distance of 8°–60° by means of a movable mercurial horizon.

1768. **Transit Instrument,** with azimuth circle, a broken telescope of 3″ aperture. (Photograph.)

A. Repsold and Sons, Hamburg.

When the instrument is inverted, which can be very quickly effected, the level and lamp remain hanging, and the binding-screw need not be loosened. There is a microscope for the eye-piece.

1769. **Transit Instrument,** with straight telescope of 3·3″ aperture. (Photograph.) *A. Repsold and Sons, Hamburg.*

In inverting it is not necessary to loosen the binding screw, and the level remains in position. A microscope is attached to the eye-piece.

1770. Transit Instrument, without case.
Prof. Dr. C. Bruhns, Leipzig, and August Lingke and Co., Freiberg.

The transit instrument is to be used in determination of time and of polar altitudes.

The iron stand is on three feet, and can be set horizontal by means of two levels at right angles to each other. On the stand is a cradle with two supports to carry the telescope, which is always horizontal. There is an arrangement by which this cradle, together with the telescope, can be inverted. In order that the inversion may be as easy as possible, a spring is fixed below the stand, which comes into play when the telescope is inverted, and carries nearly the whole weight of the cradle and telescope. On one side of the cradle is a revolving pivot, which can be brought down between two screws, and according to the position of these screws can be turned through small angles. This movement in Azimuth enables observations to be made with the instrument, not only in the meridian, but also in a vertical arc through the pole, and the index on the cradle which points to a division on the arc gives the position of the cradle in Azimuth. The graduation is so arranged that the interval between two lines gives about 10′, and can be read accurately up to whole minutes.

On the lower stand there is a boss with screws, and when the pivot of the cradle, which rests between the screws, is raised, and the screws at the same time loosened, the telescope can with ease be set in the prime vertical, and by the graduated scale the accurate position in the prime vertical can be read.

The telescope has an aperture of 78 mm., a focal distance of 80 cm., and two achromatic eye-pieces, with magnifying powers of 60 times and 90 times, also two sun-glasses. The telescope is clamped at half its length, and the clamping apparatus is so arranged that the telescope suffers no pressure. Besides, there is at the middle point of the telescope a support with two screws, in order that the telescope may rest firmly when it is clamped: by this means it has a larger base. In front of the objective is a prism (made by Schröder, of Hamburg, who also supplied the objective) giving total reflexion, and permitting the same aperture as the objective. The prism is fastened by six screws on the hypothenuse surface against a strong spring; this spring is so strong that no turning of the prism can occur while alterations owing to change of temperature may take place. On one side there are also parts against which the prism is held by two strong screws on the opposite side. In the hypothenuse surface of the prism there is a dull spot through which the central illumination of the threads is effected. By a revolving arrangement the illumination can be cut off; this arrangement is particularly simple.

The telescope carries the head of the eye-piece, and as it can have only a horizontal direction, the eye-piece must remain always in the same position. A micrometer is attached to the eye-piece which can turn through 90°; this can be used to determine micrometrically the difference of the zenith distance of stars which have nearly the same north and south zenith distance.

There are garnets in the bed plates of the supports so as to lessen the friction. For turning the telescope there is a ring of gutta-percha. The telescope carries a level, which can remain permanently on it; it is graduated to 1″·43. It has also an altitude arc graduated to 10′ and reading to 1′, by means of a vernier. The Nadir distance can be found by an artificial horizon. One turn of the screw micrometer is = $\frac{1}{100}$th of a revolution, and the pitch of the screw is about $\frac{1}{100}$th of a Paris inch.

By this instrument can be determined—

1. The time in meridian.

...es in the prime vertical.
... it is turned through 90°, the polar altitude, according to the ...thod of Bessel.
4. The polar altitude, according to Falcot's method, where the difference between the north and south zenith distance is measured by the micrometer screw.

1771. Portable Catoptric Transit Instrument, with a telescope horizontally resting in collars, and revolving only on its own optic axis. Invented and constructed by C. A. Steinheil, sen[r].

Cons... ... and Phys. Collections of B... ...).

The construction ... described by its inventor in Schumachers *Jahrbuch für* 1... ... Tübingen, published by Cotta), p. 3, *et seq.*

1771a. Reflect... ...strument.
...W. Watson and Son, London.

In this the image of the star is ... on a mirror, and then viewed by looking down through a small tele... ...ed in such a position as to be most convenient for observation; the telescope is stationary, but the mirror moves in the plane of the meridian, so can be directed to any point in it, and observations taken without those inconvenient positions of the observer, so often necessary with transits of ordinary construction.

1772. Azimuth Quadrant, constructed by Uletz in 1700.
H. G. Van de Sande Bakhuysen, Director of the Observatory, Leyden.

1773. Astronomical Quadrant, said to have been the property of Napier of Merchiston, the inventor of logarithms.
University of Edinburgh.

The telescopes attached are evidently of much more recent and clumsy workmanship than the instrument itself. They are reported to have been added by a "college baillie" (in the days when the university was under the government of the town council), who fancied that he was thereby enhancing the value of his gift to the university.

1774. Quadrant, by Butterfield, of Paris.
Kew Committee of the Royal Society, Kew Observatory.

A brass quadrant, on a wrought-iron pedestal, carrying a telescope, with object glass ½ in. in diameter, and 2 ft. 3 ins. focal length. The quadrant is divided with a diagonal scale, and is provided with a case for hanging a plumb-line.

1775. Quadrant, formerly belonging to Tycho Brahe.
Royal Museum in Cassel (Director Doctor Pinde...

This instrument is the astronomical quadrant of Tycho Brahe. ... altitude quadrant, as well as the azimuth dividing circle, are made of ...

the first is divided into sixths of a degree, the second into whole degrees, which can be read by a simple pointer, but without verniers. The radius of both circles is 40 cm., and the stand is constructed of cast iron.

1776. Two Quadrants, with double sights, old; property of H. H. Prince Pless, Fürstenstein. *Committee of Breslau.*

1777. A Quadrant, for the observation of the height of the sun, old; property of H. H. Prince Pless, Fürstenstein. *Committee of Breslau.*

1777a. Quadrant, by Langlois. *Paris Observatory.*

1778. Pillar Sextant, on stand, with artificial horizon. *John Browning.*

These instruments are intended for use in an observatory, or otherwise on land, for the purpose of obtaining accurate time.

1779. A small Semicircle, with double sights, for observing the heights of the sun, old; property of H. H. Prince Pless, Fürstenstein. *Committee of Breslau.*

1780. Model of the Greenwich Transit.

1781. Two 12-inch Astronomical Quadrants, by Bird, employed in the observations of the transit of Venus. *Royal Society.*

1782. Prismatic Circle, constructed in 1843, from the design of Professor Kaiser.
H. G. Van de Sande Bakhuyzen, Director of the Observatory at Leyden.

By means of two observations the measurement of the angle can be obtained without any instrumental error, excepting those of division. Angles can be measured from 0° to 170°.

1783. Kaiser's Prismatic Circle, constructed on the same principles as the preceding. The construction of the stand, and of a few details, have been improved in this second model.
H. G. Van de Sande Bakhuyzen, Director of the Observatory at Leyden.

d. Equatorials.

1784. An Equatorial Telescope by Abraham Sharp, an eminent mathematician, mechanist, and astronomer, descended from an ancient family at Little Horton, near Bradford in York-

shire, who was born about 1651. He was put apprentice to a merchant at Manchester, but his genius led him strongly to the study of mathematics, both theoretical and practical. By the consent, therefore, of his master, he quitted business and removed to Liverpool, where he studied mathematics, astronomy, &c., and where for a subsistence he opened a school, and taught writing and accounts, &c. He had not been long at Liverpool when he fell in with a merchant from London, in whose house the astronomer, Mr. Flamsteed, then l[illegible]harp contracted an intimate friendship with Mr. [illegible]mste[illegible]hose interest and recommendation he obtained [illegible]re [illegible] employment in the dockyard at Chatham, where he conti[illegible]is friend and patron, knowing his great merit in astronomy [illegible] mechanics, called him to his assistance in contriving, adapti[illegible]d fitting-up the astronomical apparatus in the Royal Observa[illegible] at Greenwich, which had been recently built, about 1676. He [illegible] principally employed in the construction of the mural arch, [illegible]ch in 14 months he finished, greatly to the satisfaction of Mr. [illegible]amsteed. According to Mr. Smeaton this was the first good i[illegible]trument of the kind, and Mr. Sharp the first artist who cut accurate divisions upon astronomical instruments. When it was constructed Mr. Flamsteed was 30, and Mr. Sharp 25 years of age. Mr. Sharp assisted Mr. Flamsteed also in making a catalogue of nearly 3,000 fixed stars, with their longitudes and magnitudes, their right ascensions and polar distances, with the variations of the same while they change their longitude by one degree. Among other indications of great genius, it was stated that Mr. Sharp made most of the tools used by joiners, clockmakers, opticians, and mathematical instrument makers. The telescopes he made use of were all of his own making, and the lenses were ground, figured, and adjusted with his own hands. He died July 18th, 1742, aged 91.

The Council of the Yorkshire Philosophical Society, York.

1785. Eight and a half inch Reflecting Telescope, with parabolized silvered glass mirror. *John Browning.*

Equatorially mounted, with powerful driving clock, battery of improved achromatic eye-pieces, double prism solar eye-piece for observations of the Sun. Position micrometer, and new double image micrometer, with rotating hour circle, to facilitate finding objects without calculations.

1786. Four and a half inch Reflecting Telescope, with parabolized silvered glass mirror, on parallactic stand, for following the heavenly bodies with a single motion. *John Browning.*

This instrument was contrived for educational purposes; the mirrors are warranted to be of such quality as to bear well a power of 500 diameters.

1787. Small Universal Equatorial, formerly belonging to the late Dr. W. H. Wollaston. *H. Wollaston Blake, F.R.S.*

1788. **Equatorial,** small, capable of carrying a telescope of 3 to 3½ inch aperture with perfect steadiness. *Yeates & Sons.*

1789. Equatorial arrangement of a **Refractor,** of 9″ aperture and 13′ focal length, with micrometer eye-piece. (Photograph.)

A. Repsold and Sons, Hamburg.

The declination circle can be read close to the eye-piece of the telescope; it is illuminated by the lamp which illuminates the threads in the field of view of the telescope. By means of one perpendicular roller beneath the centre of gravity, the pressure of the round axis on the bed-plate is removed. The clockwork is arranged in the head of the cast-iron column of which the first are below the floor.

1790. **Orbit-sweeper.** Equatorial arrangement of a telescope of 6″ aperture, 8′ focal length, with third axis, 1874. Constructed for the Observatory of Strassburg. (Photograph.)

A. Repsold and Sons Hamburg.

In this equatorial arrangement the head of the declination axis has at right angles to it the socket of a third axis, about which the telescope can be revolved, whilst its optic axis can be inclined to the third axis at an angle of 90° ± 2°. By means of this arrangement a heavenly body is easily found with a rapid movement of the instrument, as the third axis is directed to the pole of the projection of its orbit. (See Airy's observations on an "Orbit-sweeper," in the monthly notices of the R. Astron. Soc.) The telescope can also be placed parallel to the third axis at the head of the declination axis, and has then a simple equatorial movement. This instrument is provided with clockwork, and has a changeable polar distance from 0° to 66°.

1791. **Model of the Great Melbourne Reflector,** completed by Messrs. Grubb & Son in 1868. Scale, ¾ inch to a foot ($\frac{1}{16}$). *Howard Grubb, F.R.A.S., Dublin.*

Diameter of great mirror, 48 inches.
Focus, 30 feet 6 inches.
Form, Cassegrainian.
The ventilated tube formed of steel lattice bars.
Quick motion in declination
Slow motion in declination
Slow motion in AR
Clamping in declination
} available from eye end of telescope.

1792. **Model of the Great Refracting Telescope,** of 27 inches aperture, for the new Imperial Observatory at Vienna, now in course of construction at Mr. Howard Grubb's new Astronomical Works, Rathmines, Dublin. Scale, 1 inch to a foot ($\frac{1}{12}$th).

Howard Grubb, F.R.A.S., Dublin.

In this instrument the reading of all circles, right ascension as well as declination, is accomplished from eye end of great telescope.

Also quick motion in right ascension
" quick motion in declination
" slow motion in right ascension
" slow motion in declination
" clamping in right ascension
" clamping in declination
} All available from eye end of telescope.

The one lamp hanging in end of declination axis illuminates—

- Upper right ascension circle.
- Declination circle in two opposite sides.
- Bright and dark fields of micrometer.
- Position circle of micrometer.
- Field of 4-inch finder.

A second right ascension circle is available for reading from ground floor (south end), where also is a handle for quick setting, right ascension, and a sidereal clock face. The base of the instrument forms a chamber about 12 feet by $4\frac{1}{2}$ feet, in which is contained the clock.

1793. Photograph of a **Heliometer,** with object glass of 4″ aperture and 5′ focal length. This instrument was used by the Russian expedition for the observation of the transit of Venus, 1874. *A. Repsold and Sons, Hamburg.*

The telescope revolves on the head of the declination axis. The scales on both halves of the objective can be read by one magnifier, of which the micrometer is close to the eye-piece of th[illegible]elescope, and the same magnifier serves to read the metal thermometer o[illegible] the head of the objective. The slide bars of the objective move sim[illegible]ously on cylindrical surfaces in opposite directions. The position circ[illegible] be read and all the movements made close to the eye-piece. The [illegible]ent is mounted equatorially with changeable polar distance from 0° t[illegible] is moved by clockwork.

1794. Photograph of an [illegible]ial Refractor constructed for the Observatory in Düsseldo[illegible]. *Carl Bamberg, Berlin.*

c. Eye-[illegible]s.

1795. Eye-piece Shutter [illegible]elescopes. Allowing the aperture to be opened and closed by turning the head of the eye-piece. *Captain J. E. Davis, R.N., F.R.G.S.*

This is effected by fitting the kidney-piece with a fulcrum pin and a lever, the latter passing through the side, which is acted on by the head being turned. It obviates the necessity of the slide or kidney-piece fitted with a protruding pin, the latter frequently breaking the nail, or (with gloves on) not being felt; the pin also often loosens, and drops out.

1796. Eye-piece Heliometer.

C. A. Steinheil, Sons, Munich.

In this instrument the images are formed by means of two rectangular prisms, each of which revolves on an axis giving measurements by a screw micrometer. The prisms reflect at less than 45°, and are placed in parallel lines of light. Thus when the reflecting surfaces form an angle with each other, the pencils of rays do not issue mutually distorted, as in other heliometers, but remain centrical at all angles; also the varying distance of the mirror, and of the plan of the image has no longer an influence on the excellence of the image, which appears without parallax. A small telescope with objective prisms serves as eye-piece; it is placed parallel to the telescope axis. The mutual illumination of the image changes with the distance of the greatest diameter from the field of view, in which the images r[illegible] movable. Any illumination which is taken away from one ima[illegible] the other; the position-circle gives single minutes.

f. Micrometers.

1797. An assortment of the finest Screw-Micrometers, of almost perfect accuracy, and a small instrument for observation.

Hugo Schröder, Hamburg.

This apparatus serves for the examination of screw micrometers, and the micrometers which are exhibited are shown as examples of the great accuracy and delicacy which can be attained by cutting the screws according to the method invented by Hugo Schröder. A table showing the results of the examination of one of the screws by Dr. Vogel is subjoined.

1798. Position (Screw) Micrometer, constructed for the refractor of the Royal Observatory at Berlin.

Carl Bamberg, Berlin.

1799. Four Micrometers, for Astronomical Telescopes.

F. W. Breithaupt and Son, Cassel.

Micrometer divisions on glass, for different kinds of astronomical observation. The one with circular divisions was used by Prof. Spörer, of Anclam, for the observation of the solar protuberances at Aden during the great solar eclipse.

1800. Electro-magnetic Registering Apparatus.

M. Th. Edelmann, Physico-Mechanical Institute, Munich.

1800a. Stereo-Micrometer. Apparatus used with binocular telescopes, and measuring both angles and distances, for geodetical and astronomical measurements. Both eyes being employed, one measuring, the other observing, position and distance are thus given simultaneously. With stereo-micrometrical photographs of landscapes. *Professor Carl Wenzel Zenger, Prague.*

II.—INSTRUMENTS FOR DETERMINING THE MOLECULAR STRUCTURE OF THE HEAVENLY BODIES.

a. Spectroscopes.

1801. Spectroscope of Donati.

Royal Institute of "Studii Superiori" at Florence.

1802. Amateurs' Star Spectroscope. *John Browning.*

This instrument will show the lines in the spectra of stars of the second magnitude, when used with an object-glass only 3 in. in diameter, by detaching the cylindrical lens. The instrument may be used as a small direct vision spectroscope.

1803. Spectrum Apparatus, for the observation of the spectra of the fixed stars, planets, and nebulæ; arranged after the spectrum apparatus of Boshkamper (belonging to the Observatory of Hamburg). *Hugo Schröder, Hamburg.*

The spectrum apparatus is constructed on the simple principle which has proved so successful at the Observatory of Bothcamp, with the difference, however, that this apparatus is arranged for absolute measurement, and that the one at the Observatory of Hamburg is attached at right angles to the principal axis of the refractor.

1804. Spectrum Apparatus, for observing the **Solar Protuberances** to be attached to the collimator of the spectroscope. *Hugo Schröder, Hamburg.*

This spectrum apparatus, which is in reality a supplement of the first one, can be fastened to the collimator of the other one with great readiness. The object of this apparatus is the observation and measurement of the solar spectrum as well as of the solar protuberances. The principle on which it is constructed differs from that of the former one in that the rays after once passing through the system of prisms do not issue from it in the same direction as they entered, but are bent and scattered in favour of the heavy prisms of flint glass By means of a rectangular prism of crown glass the rays are compelled to pass through the system a second time, and leave it in a direction parallel to that of their first entrance. By a second prism of crown glass the rays are reflected into the observing tube which is attached to the prism holder. The passage of the spectrum across the field of view, as well as the absolute measurement, is effected by turning the first prism of crown glass by means of the screw micrometer. This apparatus is, on account of its convenient and highly stable construction, particularly to be recommended for observers who have scanty room at their disposition, and yet wish to undertake accurate measurements.

1805. Star Spectroscope, after Dr. H. C. Vogel (described in the Berichte der königlichen sächsischen Gesellschaft der Wissenschaften, December 1873). *H. Heustreu, Kiel.*

This apparatus recommends itself for its simple construction, for its varied application for all kinds of observations, and its reasonable price.

1806. Spectroscope made by Merz in Munich. *Prof. Dr. Winnecke, Strassburg.*

1806a. Parts of a Solar Spectroscope, made by Elliott Brothers, in 1869. *J. Norman Lockyer, F.R.S.*

In this instrument the prisms are brought to minimum deviation by means of a spring, suggested by Mr. G. W. Hemming, and the light is brought back through the prisms by a total reflection prism at the end of the train, on the plan first employed, it is believed, in this instrument, and suggested by the contributor.

1806b. Solar Spectroscope, with diffraction grating of speculum metal, presented to the contributor by Mr. Rutherfurd, of New York. *J. Norman Lockyer, F.R.S.*

1806c. Solar Spectroscope, used since 1868 in observing solar phenomena, made by Browning.

J. Norman Lockyer, F.R.S.

1806d. Slit arrangements for Spectroscopes.

J. Norman Lockyer.

d. STELLAR PHOTOMETRY.

1807. Astronomical Photometer for Extinction. Designed by Professor Thury.

Geneva Association for Constructing Scientific Instruments.

The apparent brightness of a heavenly body seen in the telescope is gradually reduced by the changeable diaphragm placed before the objective, and if necessary by the interposition of one or two dark mirrors placed behind the eye-piece in the square box, which is exposed with the diaphragm. The light is gradually reduced until the body is no longer visible. The aperture of the diaphragm is then shown upon a dial placed under the eye of the observer.

The full description of this apparatus is to be found in the "Archives des "Sciences physiques et naturelles de Genève," 1874.

1808. Zöllner's Astrophotometer, for measuring the light of the heavenly bodies by comparison with that emitted by the brightest portion of the flame of a paraffin lamp.

Earl of Rosse, F.R.S.

It being found that, though the total light emitted by the flame varies with its size, the *intensity* of the brightest part does not, appreciably. Two artificial stars are formed by means of a pin hole, a double concave lens, and a double convex lens, which appear in the field by reflexion from front and back faces of a plate of glass alongside of the image of the real star whose light passes through the plate. The intensity of the artificial star is varied, first by changing the pin hole, and finally by two Nicol's prisms, the colour being first matched with that of the star by means of a third Nicol, with a quartz plate between it and the first of the other two Nicols. The instrument is provided with object glasses of various sizes (and diaphragms) up to 2¼ inches, and, if fainter stars are to be examined, can be screwed on to the eye-piece of an equatorial instrument. A second arrangement, like the first, but without the quartz plate arrangement, forms an artificial star from moonlight, for comparison of the light of that body with the artificial star.

896. Photometer, constructed by Schwerd for the Observatory of Pulkowa. *The Imperial Observatory, Pulkowa.*

In agreement with Prof. Argelander and M. Otto Struve, the late Prof. Schwerd of Speyer constructed, in 1863, four photometers of the same size, two for Russia (Pulkowa and Wilna), the third for the Observatory, Bonn, the fourth for his own use. The principle of the construction is that of comparing the light of different stars exhibited in the same field by telescopes of different aperture. The diameter of the diaphragms to be applied before the two object-glasses, and corresponding systems of lenses, for purpose of producing equal light and colour, gives the measure of the relative brightness. The two telescopes, one of $2{\cdot}3^1$ aperture and 4 ft. focal length, the other of

1·2' apertur id 2 ft. focal length, are parallactically mounted and moved together by same clockwork (which has been left behind), so that the images of the two stars keep constantly the same place in the field during observation Being worked out in all parts with greatest care and on sound optical principles, it can hardly be doubted that this instrument answers perfectly its purpose; but on account of the great number of constants to be determined for it, its use is rather difficult Until now only two of these instruments have been practically applied, that of Schwerd himself, and the one constructed for Wilna. In both cases the first problem has been the determination of the co-efficient of extinction of light by the atmosphere of the earth.

1809. Astrometer **ting Telescopes,** invented by the contributor. *B. Knobel, F.R.A.S., F.G.S.*

This instrument has been invented termining the magnitudes of stars on the principle of limiting apertures. onsists of an equilateral triangular aperture, constructed of two plates, o ming the base and the other the opposite angle of the triangle, connec y a screw shaft of peculiar construction. The upper portion carrying angle plate, being a *right handed*, and the lower connected to the base p , a *left handed* screw. The pitch of the upper screw is *twice* that of the er. By simply turning the milled head at the end of the shaft, the aperture made smaller or larger within the limits of the triangle inscribed in the telescope tube and zero. The instrument depending on the mathematical principle $\sin 30° = \frac{1}{2}$ the aperture is thus always accurately equilateral, and concentric with the mirror or object glass. The graduated base and the micrometer head give the side of the triangle, whence the aperture is readily obtained.

1810. Astro-Photometer, according to Glan's system.
Schmidt and Haensch, Berlin.

III.—OBJECTS ILLUSTRATING THE HISTORY OF THE TELESCOPE AND ASTRONOMICAL OBSERVATION.

1811. Incomplete Telescope with broken lens of Galileo.
Royal Institute of "Studii Superiori," Florence.

1812. Compass of Galileo.
Royal Institute of "Studii Superiori," Florence.

1813. Magnet of Galileo.
Royal Institute of "Studii Superiori," Florence.

1814. Telescope of Galileo.
Royal Institute of "Studii Superiori," Florence.

1815. Object Glass (broken) of Galileo.
Royal Institute of "Studii Superiori," Flore

1816. Telescope of Torricelli.
Royal Institute of " Studii Superiori," Florence.

1817. Tube of Torricelli.
Royal Institute of " Studii Superiori," Florence.

1818. Telescope of Divini.
Royal Institute of " Studii Superiori," Florence.

1819. Telescope of Mariani.
Royal Institute of " Studii Superiori," Florence.

1820. Telescope of Campani.
Royal Institute of " Studii Superiori," Florence.

1821. Telescope by Amici.
Royal Institute of " Studii Superiori," Florence.

1822. Lens by Benedetto Bryhens.
Royal Institute of " Studii Superiori," Florence.

1823. " Primo Mobile " of Ignazio Dante.
Royal Institute of " Studii Superiori," Florence.

1824. Quadrant of Cosimo I.
Royal Institute of " Studii Superiori," Florence.

1825. Quadrant of Giusti.
Royal Institute of " Studii Superiori," Florence.

1826. Compass of Antonio Blaichini.
Royal Institute of " Studii Superiori," Florence.

1827. Graphometer of Botti.
Royal Institute of " Studii Superiori," Florence.

1828. Registering Thermometer of Fontani.
Royal Institute of " Studii Superiori," Florence.

1829. Natural Magnet of the Accademia del Cimento.
Royal Institute of " Studii Superiori," Florence.

1830. Volume, Experiments in Natural Science Accademia del Cimento. *Royal Institute of " Studii Superiori," Florence.*

1831. Telescope, by Chr. Huygens. The objective ground and polished by him, and bearing his signature.
Professor Dr. P. L. Rijke, Leyden.

Its focal distance is 3·906 m., and its opening 0·0616 m. The eye-piece is composed of three convex lenses. The lens *a*, the nearest to the objective, and the lens *b*, following it, have a focal distance of 0·105 m., and an opening of 0·04; the lens *c* has a focal distance of 0·079 and an opening of 0·038 m. The distance between *a* and *b* is 0·212 m.; that between *b* and *c* 0·182 m. The eye should be placed at a distance of 0·058 from the lens *c*. The lenses *b* and *c* serve only to rectify the images.

Telescope, by Dolland.

.elescope is the "Dollond," so often mentioned in Hum
a ut of his travels in America.

The sextant and the universal instruments was taken by Humb
all his journeys in Asia and America, and on the former depend nearly
determinations of position. It contains an inscription to this effect,
the case may still be found the paper in Humboldt's handwriting
instructions for the engraver.

This instrument, together with No. 805, and No. 1766 form a port
the Humboldt collection, with which friends in Berlin enriched th
observatory of Strasburg, erected in the year 1873.

1831b. Telescope by Campani.

Royal Museum at Cassel (Director, Dr. Pi

The tube is wood; it measures, when drawn out, 16 feet. This was
in Rome by Landgrave *Charles.*

1831c. Universal Instrument and Goniometer, b
binson. *Prof. Winnecke, Stras*

1831g. Two Telescopes (Achromatic), made by Do
about 1765, for the Russian expeditions to observe the tra
Venus in 1769.

The Imperial Academy of Sciences, St. Peter

Object glasses of 3·6″ and 2·8″ aperture, focal length 11·2′ and 8·5′.
are several of each size in possession of the Academy. As they
designated by numbers or other distinct marks, it cannot exactly be ma
which of them has been used by the different observers.

1832. Terrestrial Refractor, made by Van Deyl, at
sterdam, in the year 1781. *Foundation Teyler at Ha*

1833. The Herschel 7-foot Telescope. The origin
strument constructed by Sir W. Herschel.

Royal Astronomical So

The tube is 7 inches in diameter and 7 feet long. Both mirror
finished by Sir W. Herschel's own hands; they are sound and whole, b
much tarnished, and the large mirror was damaged in a fire some years
The framework of the stand is entire, but the moving screws, cords, &
useless in their present condition.

1784a. Newtonian Telescope, belonging to Si
Herschel, and used by him while living in Bath. He is s
have discovered the planet Uranus by its means. Focus, 7
diameter of speculum, 6½ inch. *Edwin S*

This telescope was purchased at Sir W. Watson's sale, Pulteney
Bath, about 1860. It had apparently remained after Sir W. Watson's
for some time in a lumber room of the house, and when purchased by
Smith, he discovered in the drawer of the stand a paper of directions
use of the different eye-pieces, which paper he encloses with this.

Mr. Smith adds that there was a portrait in oil of Sir W. Herschel i
of the rooms of the same house, which was sold at the same time. Dr. B
of Marlborough Buildings in this city, who was a great friend of S
Herschel, has often called on Mr. Smith to see the telescope, and repe
declared to him that this was the same instrument by which the planet U
had been discovered in 1781. It is supposed to have been made by S
Herschel, while organist in the Octagon Chapel, Bath.

1834. A 10-ft. Newtonian Reflecting Telescope by Sir William Herschel, with $8\frac{1}{2}$ inch large mirror, small plane reflecting mirror, and several eye-pieces of various powers.

Rev. Robert Main, Director of the Radcliffe Observatory, Oxford.

This telescope was made by Sir William Herschel for the Radcliffe Observatory in the year 1812, and was received at the Observatory in April 1813; Sir William himself having come to Oxford to superintend the mounting and the adjustments of the mirror.

The correspondence with Dr. Robertson, who was then Radcliffe Observer, is preserved at the Observatory.

1834a. Eight plans of the Telescope, made in London at the end of the last century, under the direction of Sir William Herschell, for the Royal Observatory at Madrid.

Astronomical Observatory, Madrid.

These plans give an exact idea of all the details of the instrument and mounting.

The speculum was of 2 feet aperture and 25 feet focal length.

This instrument was sent from London in 1801, and set up at Madrid in 1804. Four years afterwards the French converted the observatory into a fort, the telescope was destroyed, the only part remaining being the speculum.

1835. Discs of Optical Glass for Refracting Equatorial:

1 Hard crown.

1 Dense flint. *Chance Brothers & Co.*

1835a. A Series of seven Glass Parabolic Mirrors, from $3\frac{1}{2}$ in. to 15 in. in diameter, from 2 ft. to 10 ft. focus, silvered on the surfaces by Liebeg's process.

John Browning, 63, *Strand.*

1836. Compound Speculum, of 2 feet aperture.

Earl of Rosse, F.R.S.

This is one of the earlier attempts of the late Earl of Rosse to construct specula of considerable dimensions of the hardest and most reflective quality of speculum metal.

To avoid the difficulty of casting the mirror in one, a cubical block of speculum was sawed into laminæ, and these were laid side by side on a ribbed backing of a zinc-copper alloy of the same coefficient of expansion, whose surface had been previously tinned; the whole was carefully brought up to the melting point of tin, and melted tin applied to unite the whole. Though superior in rigidity to the solid metal speculum afterwards successfully constructed, it was discarded in favour of the latter, owing to the injury to definition through diffraction at the junctions of the laminæ.*

Speculum (experimental), with annulus separate from central portion, constructed for the purpose of attempting to correct spherical aberration by advancing the annulus before it had been shown to be possible to produce a paraboloid figure. Given up in favour of the *solid* speculum for same reason as the last (diffraction).

* N.B.—Another compound speculum of 3-foot aperture is still preserved, but the smaller one is sent, as the weight of the other is considerable.

1836a. Small Hand Speculum Polishing Machine, constructed and used by Sir William Herschel to polish specula of 7 feet focus (6 in. aperture). Smaller machines for smaller specula were made of this construction, and are in part preserved. The polishing machines used to figure and polish large specula (18 in. and 49 in. diameter) for the 20 foot and 40 foot telescopes used at Slough and at the Cape of Good Hope were of the same construction as this instrument and of proportionally larger size.
Prof. A. S. Herschel.

1836b. Brass foot used in place of the lead block to carry the furrowed pitch rubber or polisher revolving with the bed plate of the machine, to whose centre it is fastened down by screws. For the largest sized mirrors these brass plates were used as well as for smaller sizes to replace the lead foundation or bearer of the pitch. *Prof. A. S. Herschel.*

Eye-pieces and Objectives.

1837. Objectives and Eye-pieces of the 17th and 18th centuries, the greater part of which were ground and polished by Christian and Constantine Huygens.
Professor Dr. P. L. Rijke, Leyden.

No 1.	Objective of	120 ft.	Bearing the signature of Const. Huygens.
No. 2.	,,	34 ,,	
No. 3	,,	35 ,,	
No. 4.	,,	43 ,, 7 in.	
No. 5.	,,	13 ,,	
Nos. 6 & 7.	,,	34 ,, each	
No. 8.	,,	34 ,,	Bearing the name of Chr. Huygens.
No. 9	,,	34 ,,	Bearing the signature of Chr. Huygens.
No. 10	,,	10 ft. 8 in.	Bearing the name of Chr. Huygens.
No. 11.	Bearing the name of Hartsoeker.		
No. 12.	Objective of 32 ft		Bearing the signature of Marcell.

Nos. 1a and b.	Eye-pieces of	$7\frac{1}{2}$ and 8 inch,	to use with objective No. 1
No 2a.	,,	6	,, ,, ,, ,, 2.
No 5a.	,,	$4\frac{1}{2}$	,, ,, ,, ,, 5
No. 7a.	,,	$3\frac{3}{4}$	,, ,, ,, ,, 7.
No 8a.	,,	3	,, ,, ,, ,, 8.
No. 10a.	,,	2	,, ,, ,, ,, 10.

1838. Photograph of the **Lens** by which **Huygens** discovered **Saturn's Ring.** *Professor Buys-Ballot, Utrecht.*

This lens is stated to be the same by which Christian Huygens made out Saturn to be surrounded by a ring. It bears the inscription "X. 3 FEBR. "CIↃDCLV (Febr. 1655), Admovere oculis distantia sidera nostris."

1840. Metal for a Newtonian Reflector, with several wooden eye-pieces, but without tube or mounting, by Hadley.
Royal Society.

IV.—APPARATUS FOR DETERMINING THE EARTH'S MOTION AND DENSITY, &c.

1841. Apparatus used by Baily in repeating the Cavendish Experiment. *Royal Astronomical Society.*

Of this apparatus several parts were missing, but have been lately restored. The original portions are the long mahogany box with glazed ends for the torsion balance, and upright column in the middle for the suspension wires, and a box containing three small leaden, one brass, and two ivory balls, two brass cylinders, and one leaden lenticular weight. A full description of the apparatus will be found in the Memoirs of the Royal Astronomical Society, Vol. XIV.

1842. Gauss's Pendulum for demonstrating the rotation of the earth, executed in the year 1853 by Dr. Meyerstein.
Geodetic Institute of the Observatory at Göttingen (Prof. Dr. Schering).

V.—ASTRONOMICAL CLOCKS AND SUNDIALS.

1843. Astronomical Clock, with Sir G. B. Airy's Barometric Compensation. *E. Dent & Co.*

This clock has been fitted up with a Graham escapement; it is in other respects almost a counterpart of the new standard clock of the Royal Observatory, Greenwich.

It is found that the tendency of a clock is to gain with a high barometer, and lose with a low one. Compensation is effected in this way: there is a lever, one arm of which carries a float resting on the surface of the mercury in the cistern of a barometer tube; the other arm carries a horse-shoe magnet which faces the opposite poles of two bar magnets fastened to the pendulum bob. When the barometer rises the mercury in the cistern is depressed, so that the arm of the lever carrying the float falls whilst the other arm rises, thus bringing the horse-shoe magnet closer to the bar magnets; when the barometer falls the same action takes place in the opposite direction, thus increasing or diminishing a force acting in the same direction as gravity.

1843a. Three different Forms of Dipleidoscope. *E. Dent and Co.*

1. The simple form consists of two mirrors placed at an angle of about 60°, and in front of them a plain unsilvered glass, the whole combination being mounted, for the sake of conveniently taking observations, in a small cast metal pyramid. The optical arrangement operates in this way. Rays from the sun fall upon the front glass, and part are reflected from it and from an image; but the remaining part pass on, and meeting first one and then the other mirror, are reflected back through the front glass, and form a second image. The instrument is to be placed so that these images shall appear together in the field of view, a minute or two before apparent noon. Then what is seen is this: as the sun advances to the meridian the two images will approach, they will touch, and gradually cover one another (this observation gives the instant of apparent noon); they will continue to move on, and will finally leave one another; and each of the observations of contact, superimposition, and parting contact will be each separately and together available for determining true time. The base-plate which accompanies the instrument, it

without the current. In other systems, where the current is applied directly to move the wheel-work, a single miss of the current destroys the coincidence of time shown.

[illegible] **Ancient Sundial,** for showing the time in any latitude, scale for setting the sun's declination, and equation table.
Elliott Brothers.

1846. **Sissons' Universal Ring Dial,** for finding the sun's declination and his place in the ecliptic, the latitude of any place, and the hour of the day. *Adam Dixon.*

1847. **Two Ring-shaped Equatorial Sundials.**

[illegible] **Two Sundials,** with calendars.

[illegible] **Compass, with Sundial, of the year 1597,** with various movable discs for adjusting the zodiacal circle, &c.
Berggewerkschaftskasse, Bochum, Westphalia.

VI.—SIDEROSTATS.

1850. **Universal Heliostat,** designed by Col. Campbell, and executed by Adam Hilger, 192, Tottenham Court Road.
Lieut.-Colonel Archibald C. Campbell.

This instrument, after the polar axis has been set due north and south, and adjusted for latitude, will throw the light of a star or the sun in any required direction, and will keep it there by means of the clock; all the slow motions in altitude and azimuth can be manipulated by the observer without stopping the instrument. The connexions are placed ready to the observer's hand, wherever he may be.

A small telescope is also attached to the polar axis, so that it may act as a finder for any object, which, when seen in this telescope, will be reflected by the mirror to the required spot. The mirror is 1 foot by 8 inches, and is a perfect plane. This was also constructed by Mr. Hilger.

Dimensions.—Iron stands, 30 ins. diameter; height, 3 ft. 2 in. to centre of mirror. Mirror, 1 ft. by 8 in.

1851. **'sGravesande's Heliostat, with his Equatorial Clock.** *Conservatoire des Arts et Métiers, Paris.*

1851a. **Siderostat,** by Foucault. *Paris Observatory.*

1851b. **Heliostat,** by Gamberg. *Paris Observatory.*

1851c. **Heliostat,** by Silbermann. *M. J. Duboscq, Paris.*

1851d. **Heliostat,** by Foucault. *M. J. Duboscq, Paris.*

1851e. **Photograph of a Siderostat,** constructed by Messrs. Cooke and Sons of York, for the Royal Society.
J. Norman Lockyer, F.R.S.

VII.—CELESTIAL PHOTOGRAPHY.

a. INSTRUMENTS.

1852. The Kew Photo-heliograph, or Telescope, employed at the Kew Observatory for taking photographs of the sun's disc. *Kew Committee of the Royal Society, Kew Observatory.*

A telescope, constructed for the purpose of obtaining photographs of the solar disc. It was constructed, in 1857, by Ross, on the design and under the superintendence of W. De La Rue, Esq., at the cost of the Royal Society; and erected at the Kew Observatory, where occasional sun pictures were taken by its means until 1860, when it was dismounted, and taken to Spain, for the purpose of photographing the solar eclipse of that year. This it accomplished most satisfactorily, and a full account of its work was published in the Philosophical Transactions.

On its return to England, Mr. De La Rue established it at Cranford, where during the year 1861, almost daily, solar photographs were taken with it.

In 1862 it was again removed to Kew, and there maintained in constant operation until 1872. In 1873 it was transferred to the Royal Observatory, Greenwich, where it is now superseded by an instrument of more recent construction.

The diameter of the object glass is $3\frac{4}{10}$ ins., and its focal length 50 ins. An Huygenian eye-piece is employed for magnifying the image, and the instantaneous exposure of the plate is effected by causing a sliding plate, containing an aperture variable at will, to be rapidly drawn across the focus by a strong spring, which is released from the top by cutting a thread.

1852a. Photo-Heliograph, constructed by Dallmeyer, and used for **taking Photographs of the Sun.** This consists of a telescopic camera equatorially mounted, driven by clockwork. *The Astronomer Royal.*

The telescopic camera, total length about 8 feet, is made of brass tubing 5 inches in diameter, parallel for a length of 6 feet, when it opens out into a cone of about 2 feet in length, and sufficiently large at its extremity to receive the camera-screen, or sensitized plate, 6 inches square.

The object glass, of 4 inches aperture and 60 inches focus, corrected for coincidence of chemical and visual foci, occupies the other end of the tube furnished with the means of adjustment for focussing. The sun's image, produced by the object-glass at its focus, measures about half an inch in diameter, when it is enlarged, by a system of lenses termed a secondary magnifier, to 4 inches on the camera screen. The secondary magnifier has all the necessary appliances for adjustment of focus. The difficulty to be surmounted in this arrangement is "optical distortion" in the enlarged image, which is, happily, almost entirely overcome.

Coincident in position with the small sun's image, formed by the object-glass, are perforations in the tube for the admission of sliders, containing apertures with cross-wires, glass reticules, &c. respectively; each capable of being placed concentric with the small image. At the same place also is the instantaneous shutter arrangement for effecting the exposures. This consists of a metal slide, perforated by a slit-opening. The shutter is actuated at one end by a spring, while at the other end a string, passing over a pulley and attached to a hook, can be made to hold the spring in a state of tension. This done, on the thread being cut or burnt, the spring is allowed to act, the shutter flashes across the image forming a cone of rays, exposes the sensitized plate, and the picture is produced. There are provisions for regulating the

exposure by an alteration of the width of opening in the shutter, or by increasing or diminishing the tension of the spring.

The telescopic camera, attached to a bracket by means of two ring-clips or couplings, accurately turned, providing a motion in arc for the camera tube, read off by suitable scale and vernier, is bolted to the end of the declination axis of the

Equatorial Mounting This in outline resembles instruments constructed on the German plan, but is "universal," *i.e.*, admits of adjustment for any latitude up to 80°, either North or South of the Equator A novel contrivance has been introduced for retaining clock gearing for great variations of latitude. Briefly the instrument combines all the most recent appliances for convenience of manipulation, and, ... assive as regards construction, it may fairly be called portable. Elev... ese instruments have been sent to various parts of the world, without, i... ered, one single mishap.

1853. Complete Transit of V... nus Astronomical Equipment, as used by the English ex... ions.

The Astronomer Royal.

1853a. One of the Telescopes used in the "Transit of Venus" Expedition.

The French Co... erving the Transit of Venus in 1874.

1853b. One of the Photographic Apparatus used in the "Transit of Venus" Expedition.

The French Commission for Observing the Transit of Venus in 1874.

1853c. Photographic Revolver, used in observing the transit of Venus. *M. Janssen, Member of the Institute, Paris.*

1853d. Photographic Impressions, obtained with the revolver. *M. Janssen, Member of the Institute, Paris.*

1854. Short Focus Mirror, spherical, for telescopes, corrected by two lenses of homogenous media, for reflecting telescopes and astro-photography. With pamphlet.

Professor Carl Wenzel Zenger, Prague.

1855. Aplanatic Object Glass, 4″ aperture, 76″ focal distance, for photographing the heavenly bodies.

C. A. Steinheil, Sons, Munich.

The objective is free from chemical focus, gives perfectly correct and flat images, and is not affected by disturbing reflexions. Each half is achromatic, and consists of two cemented lenses.

1855a. Perfect Diagonal Planes (2), for reflecting telescopes. *Adam Hilger.*

1855b. Right-Angle Prisms (2), for total reflection.

Adam Hilger.

1856. Apparatus for the production of **Photographs of the Sun,** after Dr. Oswald Lohse. *A. Fuess, Berlin.*

1857. Stand with **Equatorial Motion** about a vertical and horizontal axis for a photographic lens of 6″ aperture, used by the German expedition to Kerguelen's Island, for the observation of the transit of Venus, 1874. (Photograph.)
A. Repsold and Sons, Hamburg.

The point of intersection of the horizontal and vertical axis produced is at the same time the centre of movement of the equatorial system, which consists of an hour axis and a declination arc. This arc is suspended from a double arm fastened to one end of the horizontal axis parallel to the telescope, revolving about it, and concentric with the centre of motion. As it is tied to the head of the hour axis, and revolves with it, it compels the double arm, and at the same time the telescope, to move equatorially about the horizontal and vertical axes. By this arrangement the position of a thread in the focus of the object glass can always be controlled by the level attached to the telescope. (See P. A. Hansen, "Beschreibung eines Fernrohrstatio's," &c., in the Berichten der Kgl. sächisch. Ges. d. Wiss. Mathem. Phys. A., 1 Jul. 1870.) To enable the telescope to follow the daily movement there is a screw moved by connexion with the clockwork.

1858. Small Spectrograph. Simple apparatus for taking the sun's spectrum, consisting of a camera (without objective), and a Browning's pocket spectroscope.
Professor H. W. Vogel, Berlin.

The small spectrograph serves for studying the chemical effect of the different parts of the solar spectrum upon substances sensitive to light, and for ascertaining the varying intensities of the various parts of the solar light at different places and times. The slit is wedge-shaped, in order to have more light at one end of the spectrum than at the other. The more intense the chemical effect of a colour, the further it reaches towards the dark end of the spectrum. The apparatus is held in the hand, and so directed upon the sun that the spectroscope may throw no shade. No heliostat is required. The exhibitor has been able to use the instrument on board ship, whilst sailing from Brindisi to Ceylon. (Pogg. Ann., Bd. 156, p. 321.) The exhibited apparatus has been made by *Schmidt* and *Haensch*, Berlin.

1859. Specimen Impression made with the before-mentioned apparatus. *Professor H. W. Vogel, Berlin.*

b. Photographs.

1860. Astronomical Photographs:—

a. The moon, enlarged to 80 and 100 inches diameter by the new re-photographing process.

b. The solar corona and its spectrum, photographed with short foci mirrors and objectives.

c. Solar spots, enlarged 100 times by the "Universal" Microscope, designed by Prof. Zenger, and made by Schieck, of Berlin.

Professor Carl Wenzel Zenger, Prague.

hotographs of the Arrangement for Obtaining ographs, by means of Huyghen's lens of 123 feet ength. *J. Norman Lockyer, F.R.S.*

1861. Photographs of the least refrangible end of the spectrum, by iron and other processes. *Capt. Abney, R.E.*

186 guerreotype of the **Total Eclipse of the Sun** of the f July 1851, taken at the Observatory of Königsberg. *Dr. Schur, Strassburg.*

During the ere taken. This one was formerly in the possess , late Director of the Observatory in Altona, and aft the property of his grandson, the exhibitor.

1863. Photog , taken with the Kew heliograph, and one of r determining the amount of distortion produc t.
Kew Co al Society, Kew Observatory.

The Kew Observatory f these negatives, extending from 1858 to 1872, and it is no accurately determining from them the positions and areas of ed during the 10 years 1862–1872, during which they were uninterrupt tained.

They are photographed on collod fibrine, and developed by pyrogallic acid.

The sixth picture in the frame is one of a series of views taken, of a standard scale, suspended to one of the galleries of the Pagoda in the Kew Gardens, distant 1,500 yards, for the purpose of determining the optical distortion of the heliograph.

1863a. Photographic Normal Spectrum of the Sun. Collection of enlarged comparison photographs, used in the research. *J. Norman Lockyer, F.R.S.*

1863b. The Solar Spectrum. Photograph, showing its absorption lines, by George Rutherford, of New York.
Robert James Mann, M.D.

The entire blue part of the spectrum is divided into sections, which are mounted above each other. When these are placed together in their proper continuation, the spectrum is nearly 8 feet long.

1863c. Photographic reproduction of the Solar Spectrum in its natural colours. First proofs obtained by M. E. Becquerel in 1848. (This proof, enclosed in a box, must be protected from the light.) *M. E. Becquerel.*

1864. Photographs of the less refrangible parts of the sun's spectrum, from line E downwards.
Professor H. W. Vogel, Berlin.

(3.) Photograph of a larger spectrograph, which, being in use, could not be spared for this exhibition. The accompanying photographs of the solar

spectrum had been taken on silver chloride and bromide, which had been made sensitive to the less refrangible rays through addition of light-absorbing media.

1864a. Sun spots photographed at Wilna with Dallmeyer's Heliograph. *The Observatory, Wilna.*

These photographs are made with the Dallmeyer heliograph, constructed for the Observatory of Wilna, on the designs of De la Rue. Six of these belong to the period of maximum of sun spots in September 1870, 12 other represent the largest sun spots observed during the years 1871–1875. Similar photographs are made at Wilna every bright day, under the direction of Colonel Smysloff, for promoting the study of the surface of the sun.

1865. Photographs of different parts of the Sun's spectrum.
Dr. H. C. Vogel and Dr. Chr. Lohse, Potsdam.

1866. Photographs of the Sun.
Dr. H. C. Vogel and Dr. Chr. Lohse, Potsdam.

1867. Photographs of Jupiter.
Dr. H. C. Vogel and Dr. Chr. Lahse, Potsdam.

1868. Drawing of the Spectrum of the Sun between Fraunhofer's lines H_1 and H_2, made from a photograph.
Dr. H. C. Vogel and Dr. Chr. Lohse, Potsdam.

1869. Specimens of Photographical Multiplication and **Reversion** of astronomical drawings of nebulæ and comets (Dr. Vogel's method).
Dr. H. C. Vogel and Dr. Chr. Lohse, Potsdam.

1870. Lunar and Solar Photographs. *Warren de la Rue.*

1870a. Enlarged Solar Photographs, by Mr. Rutherford of New York. *J. Norman Lockyer, F.R.S.*

VIII.—CHRONOGRAPHS.

1871. Wheatstone's Magnetic Chronograph, for measuring very small intervals of time.
Wheatstone Collection of Physical Apparatus, King's College.

1872. Groves's Chronograph, for astronomical calculations, for railway speed, and speed of machinery. *W. Groves.*

1873. Yvon Villarceau's Astronomical Chronograph.
Exhibited by Bréguet.

rrington's Astronomical Chronograph, made b Beck. *Exhibited by Dr. Stone.*

1875. Electro-magnetic Registering Apparatus.
M. Th. Edelmann, Physico-Mechanical Institute, Munich.

IX.—EDUCATIONAL.

1876. Sphere, moved by clockwork, of the Burgh Institution (1580).

1877. Sphere, rk, of Jean Reinhold (1588).

1878. Sphere bear M. Foucault's observations on the Rotatory motion

e des Arts et Métiers, Paris.

1879. Apparatus for ting the **Retrogradation** of the **Superior and Inferio ets,** also of the **Synodic Revolutions, the Transits us and Mercury, &c.**
J. J. Oppel.

The long wire represents the line o ion, the small shield at one end the apparent position of the planet, th ed ball at the other end the earth, and the movable ball the planet. The latter is fixed on the pivot of the smaller or larger turn-table, according as it is wished to demonstrate the retrogression of an inferior or superior planet. The twelve signs of the zodiac are hung up on the walls of the lecture room; the handle must be turned to the right; the angular movement of the line of vision to the right demonstrates the retrogression.

1880. Cosmographical Apparatus, to explain various natural phenomena, made by M. Robert, of Paris, and purchased for the South Kensington Museum in the Paris Exhibition of 1867.

1. The seasons.
2. The seasons.
3. Phases of the moon.
4. Eclipses.
5. Librations of the moon.
6. Real and apparent motion of the planets.
7. Fall of bodies.
8. Inequality of the seasons.
9. Precession of the equinoxes, physical.
10. Precession of the equinoxes, geometrical.
11. Precession of the equinoxes, mechanical.
12. Star to indicate a point in space.

1881. Nutoscope. Apparatus showing the laws of precession and nutation, and the conservation of the plane of rotation. With diagrams, constructed by the aid of the apparatus.
Professor Carl Wenzel Zenger, Prague.

1882. Orrery, lighted with gas, for the demonstration of eclipses, and, by the aid of a "sablier," tracing the real orbit of the moon. *Ernest Recordon, Geneva.*

This apparatus shows:

1. By means of a jet of gas behind globes, representing the celestial bodies, a sufficient shadow is cast to give a clear idea of eclipses and the phases of the moon.
2. The orbits of Venus, the Earth, and Mars.
3. The difference in length of planetary years.
4. The diurnal rotation of the Earth.
5. The two classes of planets; the smaller represented by Venus, the greater by Mars.
6. The phases of the moon. Demonstration effected by means of a flame or gas.
7. The real orbit of the moon. By means of a special contrivance, an epicycloidal line of fine sand is traced, which perfectly represents the lunar orbit.

1883. Selenographia, for showing all the effects of libration, rotation, and elongation on the surface of the moon. *John S. Marratt.*

This instrument, the invention of Mr. John Russell, illustrates the various Lunar phenomena, the libration in latitude and polar obliquity, the libration in longitude, the mean state of libration, diurnal and monthly, the periodical and synodical revolutions, and how to determine the position of polar axis, &c.

1884. Planetarium or Orrery, designed by Ch. Huygens, constructed by J. Van Ceulen, set in motion by clockwork. *Professor Dr. P. L. Rijke, Leyden.*

1884a. Planisphere, with glass globe. *A. Herbst, Berlin.*

1885. Model of the Solar System, made by Professor Kaiser for his popular lessons on astronomy. The orbits of the planets from Mercury to Jupiter are represented in their relative dimensions.
H. G. Van de Sande Bakhuysen, Director of the Observatory at Leyden.

1885a. Cosmographic Clock, reproducing all the astronomical phases of our globe, in relation to the sun. *M. Mouret, Paris.*

1887. Model devised by the Rev. **James Bradley,** Savilian Professor of Astronomy, &c., and used by him for illustrating his discovery of **Aberration.** *R. B. Clifton.*

For a description of this model, see Phil. Mag., Dec. 1846, vol. 29, p. 429.

1888. Planetarium, with clockwork. *Ernst Schotte, Berlin.*

1889. Tellurium and Lunarium, with clockwork. *Ernst Schotte, Berlin.*

...here. *Dr. H. Löckermann, Hamburg.*

... of which a more detailed explanation accompanies ... used for instruction in mathematical geography. It ...ons, and makes therefore no pretence to scientific ...nt demonstrates the apparent motion of the sun and ...portant constellations (49 constellations with 359 ... magnitude) at any given place and at any given

... Apparatus. *T. and A. Molteni, Paris.*

...rivani's Orrery, by M. Pierret.
Conservatoire des Arts et Métiers, Paris.

...s (11) for teaching Cosmography:—
...ystem.
...ystem.
...system.
...s of the sun and earth.
...s of the planets (with map of Mars).

... moon.

Ernest Recordon, Geneva.

...onomical Diagrams and Two Rules, ...tion of problems in spherical trigonometry.
Michael Elbe, Ellwangen.

...ns drawn on the maps are called astronomical webs ... contain scales. By the assistance of a diagram ... in spherical trigonometry can be solved without ...ntage in navigation. It serves also on land for the ... azimuth by means of one observation of a star.
... necessary accuracy in navigation, the drawing must ...ble by a machine, so that the accuracy of the solu... on the accuracy of the observing instrument, will ...reater precision will be arrived at by repetition, ...ng of dozens of results which depend upon just so ... the most extensive table for nautical calculation ...s which the inverse problem, often so difficult of ... by means of this apparatus.

...the Stars, southern evening winter sky, in

...ppel, and Dr. K. Oppel, Frankfort-on-Maine.

...ns of Astronomical Diagrams, for teaching. ...ck ground. *J. J. Oppel.*

... the circular plate (white on one side and black on the ...lane of illumination, at *a* at the time of the equinoxes. ...onstrates as a necessary effect of a secular revolution to ... of inclination of the earth's axis; *A* the increase of the

allurium and Lunarium.

F. Hornung, Langenbeutingen, Würtemberg.

1891. **pparatus** intended to elucidate the **Apparent Motions of** **anets** seen from the earth.

H. G. Van de Sande Bakhuysen, Director of the Observatory at Leyden.

The apparent motions of a superior planet are depicted on the inner surface of a cylinder. This apparatus was made by Professor Kaiser for his popular lessons on astronomy.

1892. Appar ting the **Path of the Moon** round the Sun, as out cusp or loop.

Dr. K. Oppel.

W ill mark, by means of a pencil to be i pentine path on a sheet of paper laid underneath.

1893. Model of the Paths **the Earth and of Venus,** with movable balls on a stand, demonstrating the position of the nodes and apses, inclination e orbit, the period of Venus, culminations, &c. *J. J. Oppel.*

1894. Armillary Sphere of brass, to take to pieces, with horizon and azimuth, meridian, equator, ecliptic, declination, and polar circles, movable sun, &c. *J. J. Oppel.*

This sphere demonstrates many of the definitions of spherical astronomy: zenith and azimuth culmination, circumpolar stars, longitude and latitude, the seasons, hour-angles, sunrise and sunset according to time and place, length of the day, &c., &c.

1895. Apparatus for demonstrating (*a*) **Foucault's Pendulum Experiment,** and (*b*) the relation between the **Period of Revolution of the Pendulum** and **Geographical Latitude.** *J. J. Oppel.*

The apparatus, placed on a common centrifugal machine and turned slowly to the left, shows the maintenance of the plane of oscillation of the pendulum as respects its apparent revolution for the spectator, a revolution which the ball of the pendulum (painted half black half red) itself does not accomplish. *b.* With a movable tangent cone the instrument demonstrates, by means of some large diagrams, that, and why the apparent angular velocity is proportional to the sine of the geographical latitude.

1896. Apparatus for demonstrating the alteration of the date in journeys round the world, from west to east. Property of His Highness Prince Pless, Fürstenstein.

Committee of Breslau.

This instrument dates from the first quarter of the 18th century.

1897. Siderial Atwood's Machine, with a ball, which represents either the moon or a planet. *Chr. Trunk, Eisenach.*

The peculiarity of the apparatus and its object explained in the description which accompanies the model.

1898. Ring Sphere. *Dr. H. Löckermann, Hamburg.*

This armillary sphere, of which a more detailed explanation accompanies the instrument, is to be used for instruction in mathematical geography. It is to serve for object lessons, and makes therefore no pretence to scientific accuracy. The instrument demonstrates the apparent motion of the sun and moon, and of the more important constellations (49 constellations with 359 stars of from first to fifth magnitude) at any given place and at any given time.

1899. Projection Apparatus. *T. and A. Molteni, Paris.*

1900. Sigr. Descrivani's Orrery, by M. Pierret.
Conservatoire des Arts et Métiers, Paris.

1901. Wall Maps (11) for teaching Cosmography:—

1. The Ptolemaic system.
2. Tycho Brahé's system.
3. The Copernican system.
4. Comparative sizes of the sun and earth.
5. Comparative sizes of the planets (with map of Mars).
6. The seasons.
7. The phases of the moon.
8. Eclipses.
9. Parallax.
10. Comets.
11. Nebulæ. *Ernest Recordon, Geneva.*

1902. Three Astronomical Diagrams and Two Rules, with scales, for the solution of problems in spherical trigonometry.
Michael Elbe, Ellwangen.

The graphic representations drawn on the maps are called astronomical webs (diagrams), and the rules contain scales. By the assistance of a diagram and a scale any problem in spherical trigonometry can be solved without working out, a great advantage in navigation. It serves also on land for the determination of time and azimuth by means of one observation of a star.

In order to obtain the necessary accuracy in navigation, the drawing must be made as exact as possible by a machine, so that the accuracy of the solution, so far as that depends on the accuracy of the observing instrument, will be fully attained. Far greater precision will be arrived at by repetition, namely, by the easy reading of dozens of results which depend upon just so many observations. Even the most extensive table for nautical calculation cannot effect this; besides which the inverse problem, often so difficult of solution, becomes a pastime by means of this apparatus.

1903. Chart of the Stars, southern evening winter sky, in Central Europe.
Prof. J. J. Oppel, and Dr. K. Oppel, Frankfort-on-Maine.

1904. Specimens of Astronomical Diagrams, for teaching. White figures on black ground. *J. J. Oppel.*

In both instruments the circular plate (white on one side and black on the other) represents the plane of illumination, at *a* at the time of the equinoxes. The arrangement demonstrates as a necessary effect of a secular revolution to the right of the plane of inclination of the earth's axis; A the increase of the

ongitude of the stars; B the difference of the sidereal and tropical year; C the change of the pole star. The long wire at *a* can be fixed either in the direction of the pole (for A) or of the earth's axis (for C). The plane of the ecliptic is supposed horizontal; the appliance *a* must be turned to the right slowly on its pivot.

1906. (1.) **Diagram for Nautical Astronomy,** engraved on stone; with a printed explanation. (2.) Diagram of Nautical Astronomy. Handbook of Practical Nautical Astronomy.

1907. Orrery, by Cole: explanatory of eclipses.
Royal Society.

1908. Cele
Berlin (Reimer and Hoefer).

1909. Celestial Globe of m. diameter, with complete equipment. *Dietrich Rein. Berlin (Reimer and Hoefer).*

X.—ASTRON DRAWINGS.

1910. Unfinished **Chalk Dr gs of Lunar Craters,** made with the reflector of 3 feet aperture, Parsonstown, by **Mr. Samuel** Hunter, assistant in 1860 to 1864. *Earl of Rosse, F.R.S.*

1910a. Chart of the Moon, drawn by hand by Tobias Meyer.
Prof. Dr. Winnecke, Strassburg.

The highly interesting chart of the moon is the original drawing by Tobias Meyer, executed in the year 1750, which served for more than half a century as copy for all the maps of the moon used in nearly all the text-books. The autograph remarks on it, by the well-known Professor Ticktenberg, of Göttingen, show how and where the chart was preserved during the last century. It came into the possession of the exhibitor by a legacy of the late Privy Councillor Eisenlohr, of Carlsruhe.

1910b. Landscape of the Moon in relief, by Witte.
Prof. Dr. Winnecke, Strassburg.

This view of the moon was executed by the celebrated Lady Frau Hofrath Witte, in Hanover, after her own observations. After her death it was presented to the exhibitor by her daughter Frau Stadtrath von Mädler.

1910c. A Series of Astronomical Engravings, from the Observatory of Harvard College. *J. Norman Lockyer, F.R.S.*

MODELS, &c. OF ASTRONOMICAL INSTRUMENTS.

1911. Model of one of the three **Smaller Domes** for the new Imperial Observatory at Vienna, now in course of construction at Mr. Howard Grubb's Works, Rathmines, Dublin. Scale, 1 inch to a foot. *Howard Grubb, F.R.A.S., Dublin*

This dome is supplied with Mr. Grubb's improved shutter, by mea which, being perfectly balanced in all positions, the shutters of dome are as easily managed as those of drum roofs.

This is accomplished by a set of counterpoises, equal in the aggregate to the whole weight of the shutter, which are lowered one after another into the place prepared for them. When the shutter is half open all the weights are deposited, the shutter being then balanced in itself. The chains then lap round a roller prepared for them, and as the shutter opens still further the weights are again raised up one by one as the shutter gets heavier and heavier towards the back.

If desired, this form of roof can also be made to open beyond the zenith by placing a pair of doors at base of shutter "chase," which open automatically, and allow the shutter to roll back.

1912a. 11 Photographs of the buildings of the Observatory and its principal instruments. *The Pulkowa Observatory.*

1912b. 10 Photographs of several auxiliary instruments lately constructed by M. Herbst, at the mechanical workshop of the Observatory. *The Pulkowa Observatory.*

1912c. Photographs of Mr. Newall's Observatory. *J. Norman Lockyer, F.R.S.*

1912d. Photograph of Galileo's Tribune at Florence. *J. Norman Lockyer, F.R.S.*

1912e. Photographs of the Old Astronomical Circles at Delhi. *Mrs. Norman Lockyer.*

1912f. Photographs of the Lamp in the Cathedral at Pisa (interesting in connexion with Galileo's observations). *Mrs. Norman Lockyer.*

1914. Three Photographs of Astronomical Universal Instruments. *F. W. Breithaupt and Son, Cassel.*

Astronomical universal instrument, portable. The movable circles have each two magnifying lenses for reading the seconds; the vertical circle is 33 cm., and the horizontal 50 cm. in diameter. The broken telescope has an aperture of 67 mm. and a focal distance of 80 cm., and is illuminated through the axis. The instrument revolves on the vertical axis; the horizontal axis is balanced on one plate only, and is invertable on spring rollers. One level rests on the horizontal axis, a second is attached to the carrier of the magnifying lens, and a third can be inverted on the same. The second vertical axis which serves as a counterpoise is graduated. The instrument itself was made in the year 1873 for the Japanese Government in Yokohama.

(2.) Astronomical universal instrument, portable.

This instrument is provided with two movable circles, of 25 cm. diameter, each having two magnifiers, with a side telescope of 27 mm. aperture and opposing vertical circle, the carrier of the magnifying lens being in the middle. By this arrangement the upper part of the instrument is kept low; it has also the advantage that, without alteration of position, the telescope, the two circles, as well as the numerating circle, can be observed. This instrument was constructed in 1875 for the Royal Mining Academy at Schemnitz.

(3.) Universal instrument, portable.

The circles are 20 cm. in diameter, the vernier reads to 10 seconds, the telescope of 40 m. aperture is at the side, the azimuth circle is movable and

the le attached to the telescope. All the verniers are covered wi the alhidada of the vertical circle has a separate level. The im was made for the Imperial Observatory at Strasburg.

1914a. Photographs of Chinese Astronomical Instruments, enlarged by the Autotype Company from the original photographs by J. Thomson, F.R.G.S. *Autotype Company.*

No. 1. Ancient armillary sphere in the court of the observatory, Peking. This instrument was made under the direction of Ko-show-king (during the Yuen ol dynasty, about the close of the 13th century), one of the mos tory, and at the time chief of the astr d bronze, of hugh dimensions and exq work tal horizon crossed at right angles by a double ring rms the outer framework. The upper surface of the h into 12 equal parts marked with cyclical characters, th urs into which the Chinese divide the day and night. se are eight characters of the denary cycle and four of the ous eigh s of the Book of Changes. The inside of the ring bea the names 2 states into which China was in ancient time divided. An equator is fixed inside the frame, within which a sphere turns on two pivo poles of the azimuth. This is made up of an equatorial cir ring ecliptic, an equinoctial circle, and double ring solstitial quator is divided into 28 unequal portions marked by the nam mber of constellations of unknown antiquity. The ecliptic is divided into equal parts. All these circles are divided into 365¼ degrees, corresponding to the days of the year, and each degree is divided into 100 parts, as the centenary division prevailed for everything less than degrees, till the arrival of Father Verbiest in the 17th century.

No. 2 Armillary sphere on the terrace of the observatory at Peking, made under the direction of Father Verbiest; *see* Thomson's "Illustrations of China "and its People."

No. 3. Celestial globe on the terrace of the observatory at Peking; *see* Thomson's "Illustrations of China and its People."

1914b. Model of Hipparchus' Astrolabe, showing how that astronomer observed longitudes, and was enabled to determine the processsion of the equinoxes. *J. Norman Lockyer, F.R.S.*

1914c. Two Photographs of the 25-inch Refractor constructed by Messrs. Cooke & Sons, of York, for Mr. Lewall, of Gateshead-on-Tyne. *J. Norman Lockyer, F.R.S.*

1914d. Collection of Photographs, illustrating various expeditions for observing Total Eclipses of the Sun.
J. Norman Lockyer, F.R.S.

1914e. Three enlarged Photographs of the Moon, by Mr. Rutherford, of New York. *J. Norman Lockyer, F.R.S.*

1915. Atlas Cœlestis Novus. Stellæ per mediam Eur solis oculis conspicuæ secundum veras lucis magnitudines e ipso descriptæ ab Eduardo Heis D. Math. et Astro. Prof. P. C

Academia regia Monasteriensi Coloniæ 'ad Rhenum 1872, impensis M. Du Mont Schauburg. Catalogus Stellarum.

I. Two volumes bound.

II. Thirteen plates for hanging on the wall.

Prof. E. Heis, Münster.

The Atlas Cœlestis Novus, the result of observation extending over 27 years, gives the appearance of the starry heaven as it is seen at the present day with the naked eye. It is more especially remarkable for containing, besides the stars of the 1st, 6th magnitude, those also of the 6th and 7th magnitude, which the author himself can easily distinguish. All the stars, without exception, are compared with one another in respect of magnitude by the naked eye, with the additional employment of other means of assistance; thus, among others, has been used the "method of sequences" of Sir John Herschel (*see* Results of Astronomical Observations at the Cape of Good Hope). The total number of stars observed by the author is 5,421, or 2,153 more than will be found in Argelander's Nova Uranometria. As no single star has been entered which has not been many times observed and compared, future observers will be able to judge whether in the course of centuries the sky has changed, whether any of the stars get brighter or darker, whether some have disappeared, or others come into view.

The author has paid particular attention to draw the milky-way with the greatest accuracy, and to make the brightness of the different stars in 5 degrees. For this purpose, the drawings made by Sir John Herschel of the milky-way in the southern sky were taken as models. The figures of the old constellations are copied from the classic figures on the celestial globe in the Farnese Museum at Naples. In the catalogue of the stars arranged according to the 57 constellations, their right ascensions and declinations, (Aug. 1855) are given; there are added also the numbers of Bayer and of Hamstur (according to Miss Caroline Herschel); and also the numbers in the catalogue of the British Association for the Advancement of Science, and other catalogues.

1916. Chronometrograph, for the determination of true time. (Original drawing.) *Prof. Dr. Prestel, Emden.*

1917. Pictorial Representation of the Solar System, for the demonstration of the relative sizes of the sun and planets, also of the relative distances of the planets from the sun, and of the inclination of their orbits to the ecliptic. (Original drawing.)

Prof. Dr. Prestel, Emden.

1917a. Photograph of the Sun, by Mr. Rutherfurd, taken with his triple combination. *J. Norman Lockyer, F.R.S.*

1917b. Enlarged Photographs of the Sun, taken by M. Janssen. *J. Norman Lockyer, F.R.S.*

1917c. Photograph of the Sun, taken by Professor Winlock, by a simple lens of 40 feet focal length.

J. Norman Lockyer, F.R.S.

1918. Chart of the whole Celestial Sphere in epicycloidal projection. *Dr. F. August, Berlin.*

This map gives a simultaneous view of the whole sidereal heaven. Each

constellation preserves its proper form, for the representation is conformable, that is, proportional in the smallest parts. There is no want of conformity at any point, not even at the poles, so that even there the meridians cut each other at the correct angle By this means the spherical form is always pictured to the eye; the arrangement of the map is easily imagined, by supposing an elastic envelope to be stretched about a celestial sphere, then cut open and stretched on a frame. The course of the milky-way which follows one of the great circles of the heavens, and the parts comparatively free from stars which are at the poles of this great circle, are very well represented by means of this map. The map contains the stars from the first to the sixth magnitude.

The mathematical considerations which are necessary for accurately understanding the construction of the map will be found in the accompanying treatise: Ueber eine conforme *Abbildung der Erde nach der epicycloidischen Projection.* (Extract from the *Zeitschrift für Erdkunde,* Vol. IX., Berlin, 1874, published by Dietrich Reimer.

1919. Treatise on a **Conformable Representation** of the **Earth** by **Epicycloidal Projection.** (Extract from the Zeitschrift für Erdkunde, vol. IX., Berlin, 1874.)

Dr. F. August, Berlin.

XI.—MISCELLANEOUS.

1920. Vinot's Sideroscope. *T. and A. Molteni, Paris.*

1921. Apparatus, constructed by Professor Kaiser, for determining the absolute value of personal errors in observations on the transit of stars.

H. G. Van de Sande Bakhuysen, Director of the Observatory at Leyden.

The moment of the transit is registered by the action of a current. The construction of this instrument dates from 1856; the first observations were taken in 1859. (Dutch Records, Tome I., p. 193.)

1922. Observing Seat for Reflecting Telescopes, invented by the contributor. *E. B. Knobel, F.R.A.S., F.G.S.*

The observer sits as on horseback, and by simply raising himself off the seat, standing on the ground or on the movable footrests, as if in his stirrups, he can easily pull the seat up under him, and adjust it to the required height, without dismounting or moving from the eye-piece of the telescope. Releasing the ratchet wheel allows the seat to be lowered to any position.

1922a. Collection of Compounds of Silicon with various **Metals** for optical purposes.

1922b. Fittings for **Astronomical Telescopes.**

M. Lutz, Paris.

1923. Cooke's Lamp for illuminating the micrometric spider webs of astronomical telescopes. *A. A. Pearson, Leeds.*

The lamp is inserted in the brass body of the instrument, where it is held

by two projecting catches. The light, after passing through a condensing lens, is received by a rectangular prism placed at such an angle that the beam is totally reflected downwards into the window of the telescope, where its intensity and colour are modified by diaphragms. The lamp is suspended on a pivot, and also the framing and prism-box revolve from the bottom of the supporting pillar, so that it has a universal motion accommodating it to the position of the telescope. The weight of the end counterpoises the lamp, and the one at the side is the gravity poise. The top of the lamp is movable, and has attached a small tin chimney, which assists in promoting a draught and keeping it cool.

1924. Perpetual Almanac.
(Directions for use printed at the back.)
Gust. Schubring, Erfurt.

1924a. Calendar for Two Thousand Years.
M. Georges Sarasin, Geneva.

Lithographed sheet, framed and glazed, permitting the sight, by three openings, of portions of a second lithographed sheet which is capable of movement round a spindle issuing from the right side. These lithographed sheets are divided into sectors of a circle radiating from a common centre, which is at the same time the centre of motion of the second. They are covered with figures and explanations. An inscription denotes briefly the method of use.

Use.—If, by the motion given to the central disc by means of the spindle, the two figures which express the tens and units of a year, and the figure which constitutes—or the two figures which constitute—the hundreds (whether according to the Gregorian or Julian style), be brought into such a position that the latter be to the left and the former to the right, the calendar of that year will be given on the lower portion of the sheet. The days of the week will correspond to the days of the month in the radial direction, and to the months in the circular direction, whichever of the two styles may have been chosen. There is no occasion either to give a new movement to the disc, or to take into consideration the dominical letter, which is only a digression. Two of these *data* being given, the third may be found. When the three *data* are given, the years may be found, which, since the Christian era, have possessed them together.

The months of January and February are distinct according to whether it be a bissextile or ordinary year that is in question. In the former case, the tens and units figures, divisible by four, are separated by an empty space from the preceding in the table of years. A third designation of the two abovementioned months is also perfectly suitable to the two classes of years, if the date of the year immediately preceding be formed by the movement of the disc.

It may also be ascertained to what day of the ordinary week corresponds any date during the thirteen years of the Republican style which followed the year 1792, by taking for the hundreds portion the zero of the Julian style.

1924c. Calendarium Perpetuum Mobile, eight Tables in glazed frame and in a stand. *Ch. A. Kesselmayer, Manchester.*

A perpetual calendar, which gives the solution of any chronological problem during a period of from 10,000 years before to 100,000 years after Christ. The tables, which are still in course of construction, will contain the principles of a "Standard Calendar," as invented by the author, the object of which is to demonstrate the errors and inaccuracies both of the Julian and Gregorian calendars.

Tab. I. Adjustable universal calendar key.
Tab. II. Adjustable annual calendar.
Tab. III. Adjustable astronomical calendar of the northern zone.
Tab. IV. Table for discovery of the theoretical epacts.
Tab. V. Table for finding the epacts to be applied.
Tab. VI. to VIII. contain : explanations and examples of the Calend. Perp. Mob.; adjustable universal calendar; adjustable indicator of dates; adjustable cylindrical indicator of week days; adjustable perpetual pocket calendar; annual pocket calendar for the year 1877; calend of the week days.

1924d. Reproduction [illegible] **Books on Astronomy,** written by Dr. Alonso el Sab[illegible]h century, from the original MS. at the Escorial. [illegible]*ademia de Ciencias, Madrid.*

"Libros del Saber de astronomia [illegible] Don Alonso el Sabio" 5 vol., gr. in fol., Madrid.

These volumes contain an extensiv[illegible]nt of astronomical science in the 13th century, the plates reproduce a[illegible]her details the constellations there known, and the astronomical instru[illegible]ed at the time.

1924e. A reproduction [illegible] **ster of a fragment of the Zodiac (Aries).** The original [illegible]stone, is at the Archæological Museum at Madrid. [illegible]*æological Museum, Madrid.*

This was found, with other objects of a very remarkable kind, at Yecla, in the province of Alicante (Spain). It has an inscription in old Greek characters relating to the subject.

SECTION 12.—APPLIED MECHANICS.

SOUTH GALLERY.—GROUND FLOOR, ROOMS B. C.

I.—PROPERTIES OF MATERIALS.

1925. Chinese Steel Helmets (2).
Bennet Woodcroft, F.R.S.

1926. Chinese Cane Helmets (2).
Bennet Woodcroft, F.R.S.

1927. Cast-iron Test Bars. Specimens to illustrate the forms and positions of fractures when exposed to a breaking load.
W. J. Millar, C.E.

The bars were of 36″ span, 2″ deep, and 1″ broad.
The load was applied at centre of bars. Straight fractures occurred when bars broke at, or close to, centre of span; curved fractures followed when bars broke at points more or less removed from centre.

1957b. Drawings of Hydraulic Apparatus for the study of the extension, compression, and flexion of prismatic bars. Constructed by Professor Wischnegradski.
Laboratory of Mechanics, Technological Institute, St. Petersburg.

This apparatus consists of a hydraulic cylinder, the piston of which bears a table supporting four iron columns, connected at the top by a strong cast-iron cross piece, that has at the centre a conical opening, and below a spherical excavation within which pivots a hemispherical cast-iron piece, traversed by a powerful iron screw fixed by two nuts; to this screw is attached the upper end of the bar subjected to the experiment of extension; the lower end of the bar is fastened to the large lever placed at the base of the apparatus and which pivots round an axle fixed in an immovable bearing. This lever is connected with the upper lever, by means of two iron braces suspended to one end of this lever; at the other end are hung a scale board for the weights used in calculating the tension effected. The ratio of the two arms of the lower lever is 5, and that of the two arms of the upper lever is 20. So that each lever being perfectly balanced the tension of the bar is exactly 100 times that of the weight on the scale board. By means of the screw described above, and by inverting the intermediate iron pieces, it is possible, with this apparatus, to experimentalise upon bars of any length provided they do not exceed 10 feet English.

[illegible] 1 represents the apparatus arranged for experiments of [illegible]

[illegible] No. 2 represents the apparatus arranged for experiments of flexion.

Drawing No. 3 represents the apparatus arranged for experiments of the compression of long bars.

The deformations in the bars occasioned by this apparatus are measured with a cathetometer constructed by Mr. Brauer, and the primitive section of the bar with an apparatus by the same engineer. The correctness of all these registerings is given in $\frac{1}{100}$ of the millimeter.

II.—[illegible]LECTIONS.

COLLECTION OF THE ORI[illegible] [illegible]ELS OF STEAM ENGINES AND OTHER MACHINES O[illegible] [illegible]WATT. PRESENTED TO THE SOUTH KENSINGTON M[illegible] [illegible]Y GILBERT HAMILTON, ESQ.

1928a. Imperfect [illegible] [illegible]ethod of converting reciprocating into rotative mot[illegible] [illegible] of teeth or pins fixed to the connecting rod, which take [illegible] teeth in a wheel, and cause it to revolve. Some point of [illegible] connecting rod being guided by a pin, moving in a groove, so as [illegible] keep the teeth or pins always engaged in the teeth of the wheel.

This method of converting reciprocating into rotative motion is included in Specification of Patent granted to James Watt, dated October 25th, 1781.

1928b. Two Fragments of a Model, consisting of wood rods with oval holes geared internally, and apparently belonging to one of the models selected from the Soho Works by the late Sir Francis Smith, as an illustration of one of the methods of converting reciprocating circular motion.

1928c. Model of Grinding Mill, 6 pairs of stones in two sets of 3 pairs each, each set driven by a spur wheel with bevil gearing. The two fly wheels are connected and driven by pin and connecting rod.

1928d. Model of Grinding Mill, with six pairs of stones, in two sets of three pairs each. Each set driven from one spur wheel by bevelled gearing.

The two fly wheels are connected, and driven by one connecting rod, fitted with two sets of stepped sun and planet wheels.

1928e. Model of Rolling and Slitting Mill, driven by two connecting rods, on one beam, and fitted with sun and planet stepped gearing.

This improvement, consisting of new methods of applying the power of steam engines to move mills for rolling and slitting iron and other metals, is included in Specification of Patent, granted to James Watt of Birmingham, and dated April 28th, 1784.

1928f. Model of Rolling Mill, driven by a connecting rod, fitted with stepped sun and planet motion, and with two fly wheels.

1928g. Model of two Tilt Hammers, at right angles to each other, one hammer actuated at the tail by cams, the other by lifting cams, driven by one connecting rod fitted with stepped sun and planet motion.

NOTE.—Part of the above model is missing, and the helve of one tilt hammer is broken.

1928h. Model of Wheel (probably for grinding). With sliding axle.

1928i. Fragment of Model (probably a pump bucket).

1928k. Models on a Stand, of four trussed beams, probably used experimentally for testing the strength of different methods of trussing.

1928l. Fragment of a Model of a Frame for a Machine.

1928m. Fragment of a Frame.

1928n. Model of a Horse Mill, with roller and trough, apparently designed for crushing material.

1928o. Model of a Train of Wheels.

1928p. Model of Beam and two connecting Rods with universal motion at their upper ends, and connected to transverse hinged links at their lower ends.

1928q. Model of Beam Pumping Engine, single acting and condensing, worked by tappet valve motion.

1928r. Model of double acting Beam Condensing Engine, conical valves worked by eccentric.

1928r. Model of inverted Cylinder, direct acting pumping engine with tappet valve motion.

1928s. Sectional Model of Beam Engine, worked by eccentric and hollow valve.

1928t. Sectional Model of Engine, with shifting eccentric for altering valve.

1928u. Model of a Pair of Tilt Hammers, alongside each other. Two beams and connecting rods, with cranked pins at an angle to each other, and one of the wheels provided with a balance weight.

(NOTE.—Part of the above m g.)

1928v. Fragment of a M l with part of Sun and planet motion.

1928w. Fragment of a l with Sun and planet motion and weighted disc.

1928x. Fragment, an ar d.

1928y. Model of a Wate eel.

1928z. A Measuring Apparatus, with Micrometer Screw, for taking end measures.

1928aa. Model of Garnet's Patent Friction Rollers.

1928bb. Model used for Testing Pressure due to Vacuum.

1928cc. Model of Valve with Universal Joint.

1928dd. Brass Model in two Pieces.

1928ee. Model used in experiments on Governor.

1928ff. Experimental Model.

1928gg. Experimental Model.

1928hh. Experimental Model.

1928ii. Original Model of Cylinder with separate Condenser.

1928jj. Model of Surface Condenser.

III.—PRIME MOVERS.

1930. Original **Model** of **Stirling's Air-engine.** Made by the inventor. *University of Edinburgh.*

1931. Rotary Steam Engine. Designed and made by the Rev. Patrick Bell.
Lent from the Patent Office Museum by the Commissioners of Patents.

1932. Sectional Model of a **Cabinet Steam Engine.**
Lent from the Patent Office Museum by the Commissioners of Patents.

This is a sectional model of a steam engine in the Patent Office Museum, and was made for the purpose of showing the following improvements in the steam engine made by James Watt. (The engine in the Patent Office Museum was the property of James Watt.) Improvements above referred to:—

a. Making the engine double acting.
b. Keeping the cylinder heated while the engine is at work by surrounding it with steam.
c. Using a separate condenser and air pump.
d. Parallel motion.
e. The governor.
f. The D slide valve.

1933. Drawing of "Head's Patent Prime-mover."
Jeremiah Head, M.I.C.E.

Being an inverted, direct-acting, non-condensing steam-engine, with steam-jacketed cylinder and covers, cylindrical slide valves, and variable expansion gear, controlled by a liquid-cataract parabolic governor, and balanced throughout for running at a high speed.

1934. The **Locomotive Engine "Rocket,"** constructed, by Messrs. Stephenson & Co. in 1829, to compete with other engines on the Liverpool and Manchester Railway, where it gained the prize of 500*l*. The Liverpool and Manchester Railway was formally opened for passenger traffic on the 15th September 1830.
Lent from the Patent Office Museum by the Commissioners of Patents.

1934a. The Puffing Billy, the oldest locomotive engine in existence, and the first which ran with a smooth wheel on a smooth rail, was constructed in 1813 by *Jonathan Foster*, under *William Hedley's* patent, for Christopher Blackett, Esq., the proprietor of the Wylam Collieries near Newcastle-upon-Tyne. This engine, after many trials and alterations, commenced regular working in 1813, and with tender and two trucks, a total load

amt fifty tons ran, at an average rate of six miles an hou ?) was kept at work until the 6th June 1862, and was then purchased for the Patent Museum.

H.M. Commissioners of Patents.

1935. Wood Model of **Disc Engine.** (Taylor and Davies' Patent, 1836.) *Bennet Woodcroft, F.R.S.*

1936. O iginal Model of **Trevithick's Locomotive Engine.** (Trevithick's Patent, 1802.)

Bennet Woodcroft, F.R.S.

1937. Model of a **Calc ine** (unfinished).

Bennet Woodcroft, F.R.S.

pparatus for **Locomotive En** *Bennet Woodcroft, F.R.S.*

1939. Models (2) of **Rot ngines.**

Bennet Woodcroft, F.R.S.

1939a. Model , of great adherent power, working by means of six clogs.

M. lphe Fortin Hermann, Paris.

(This model belongs to the Conservatoire des Arts et Métiers.)

1940. Working Model of **Stirling's Air Engine,** presented by the inventor, the Rev. Robert Stirling of Galston, to the Natural Philosophy Class of Glasgow University, and used constantly for lecture illustrations. *Sir William Thomson.*

1941. Model of **Dawes' Compound Stationary Engine.** In this the low-pressure cylinder is horizontal, and the high pressure is arranged over it, at an angle of 30° to the centre line of low pressure. The connecting rods couple to a single crank; the air pumps and condensers are driven off the low pressure crosshead, and being two in number are arranged on each side of connecting rods. *Henry S. Holt, C.E., Leeds.*

1942. Model of Agricultural Locomotive Engine, fitted with patent side-plate brackets. *Aveling and Porter.*

This represents one of Aveling and Porter's road locomotive engines. The *single* cylinder is placed on the forward part of the boiler, and is surrounded by a jacket in direct communication with it; the steam is taken into the cylinder from a dome connected with the jacket. Priming is by this means prevented, the use of steam-pipes either inside or outside the boiler is rendered needless, and a considerable economy in fuel is effected. The crank-shaft brackets are formed out of the side plates of the fire-box extended upwards and backwards in one piece, so as not only to carry the crank-shaft, but to provide bearings also for the counter-shaft and driving-axle, in the most convenient position. This arrangement produces a combination of much strength and lightness, reduces to a minimum the loss and annoyance from leakage at strained bolt holes, and unites all parts, peculiarly exposed to

injury by jarring, with such firmness as to give almost absolute security against such injury on even very rough roads. The driving wheels are of wrought iron, and are fitted with compensating motion for turning sharp curves without disconnecting either wheel; they carry about 85 per cent. of the weight of the engine. The engine is steered from the foot-plate. The boiler is made of best quality plates, and tested with cold water to 200 lbs. on the square inch; the fire-box is of Lowmoor iron.

1943. Original Model of Newcomen's Steam Engine.
Council of King's College, London.

1943a. The Pulsometer (Hall's patent).
Hodgkin, Neuhaus, and Co., London.

Self acting steam pump, a novel application of the general principle involved in Savery's engine, A.D. 1702. The result is produced by the pressure of the steam from the boiler upon the surface of the water in each chamber of the pump alternately, without the intervention of any steam piston or plunger, and the water is lifted into the chambers by a vacuum produced without injection or surface condensation. The action of the steam ball which governs the pulsations is purely automatic, and the moving parts, including four valves, are only five in number.

1944. Model of Captain Savery's Steam Engine. This form is a modification by Dr. Desaguliers, constructed about 1717. The first complete engine of this kind was made for the Czar of Russia (Peter the Great), for his garden at Petersburg. 1717 or 1718. *Council of King's College, London.*

2137. Model of a **Direct-acting Cornish Pumping Engine,** with cataract.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

This (also with open cylinder) has a cataract of simple construction, and a systematically arranged valve motion.

The model serves, in the first place, to illustrate the general nature of click-trains used as valve gear, and their application by means of a plug rod and tappets worked from a beam. It also shows in particular the mode of employing a condenser in a single-acting engine, where three valves (admission, exhaust, and equilibrium) are necessary, with their three separate weigh shafts and wipers, clicks, weights, and levers. The commencement of the expansion is shown very distinctly by the closing of the admission valve. The pause at the end of the "indoor" stroke is effected by means of the cataract, which is filled with petroleum; the action of this mechanism can be very distinctly observed. With a slow motion of the cataract, it can also be easily noticed that the exhaust valve opens a little sooner than the steam valve, in order that a sufficient vacuum may exist upon one side of the piston before the steam is admitted upon the other.

The condenser itself is omitted in order to simplify the model and to make the complicated valve gear somewhat more easy to understand. A lever for the injection valve only is shown, to show that this valve must be opened before the engine can start.

For simplification, the cataract which determines the short pause at the end of the "outdoor" stroke is also omitted.

...tionary Direct-acting Steam Engine (model).

... Geological Institute and Mining Academy (Director, ... rof. Hauchecorne), Berlin.

The cylinder and valve chest are opened so as to show the various parts. The eccentric is displaceable with reference to throw and lead; accordingly the valve rod and valve are changeable.

This model ... hows the general arrangement and essential details of a stationary di... t-acting engine, and is arranged specially to demonstrate the relat... s and positions of the piston and the slide valve, and the mech... nected with them.

It ...:

1. The dead points of the ...
2. The necessary relative ... entric and crank;
3. The way in which a steam ... mpelled to move in one direction.
4. The lead of the valve and the ... ic, and their influence upon the steam admission;
5. The lap of the valve and its co... with the angular advance of the eccentric and the expansion ... eam;
6. The irregularities in steam ... ion and in the transmission of motion to the fly-wheel, cau... e obliquity of the connecting-rod; and
7. The effects upon the steam ... m of an eccentric rod of wrong length or an eccentric put ... g position.

1944a. Working Model of latest improved horizontal high-pressure coupled winding engines for coal, copper, iron, salt, and other mines. *Messrs. Robert Daglish and Co., Lancashire.*

2141. Model of a Horizontal Steam Engine, with reversing gear (Gooch's link).

Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

This model is intended to illustrate the action of the link motion generally, and especially that with adjustable block.

The link can be worked in two ways. Either its centre can be suspended and an eccentric rod connected with each of its ends, or its centre can be fixed, and one eccentric rod only used; an arrangement often employed, for example, in hoisting engines.

It shows very distinctly that with two eccentric rods with their eccentrics placed 180° apart, the centre of the link moves to and fro, and that this error can be almost entirely prevented by giving the eccentric a little advance.

2143. Horizontal Steam Engine, with reversing gear (Stephenson's link).

Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

Along with the above model this shows the two chief systems of link reversing gear, their differences, and their comparative advantages and defects. The link has here a different form to that employed in the last case, partly simply for the sake of variety, and partly to show the influence of the position of the point of suspension upon the motions of the link.

Models of mechanisms:—

The eccentric is here also adjustable for variations of lead.

1945. Atmospheric Gas Engine. Otto Langen and Crossley's joint patents. Actuated by the vacuum resulting from the explosion of common coal gas and air. *Crossley Brothers.*

In this engine, which works by the vacuum resulting from the explosion of common coal gas and air, the piston is not, as is usual, connected with the shaft on both up and down stroke, but on down stroke only. It is thus at liberty to fly up freely from the force of the explosion, which takes place at the bottom only, and by driving the piston before it empties the cylinder of air through its open upper end. The return of the air on the down stroke yields the driving power, and turns the shaft by means of a friction clutch, to which the piston is geared by the rack. The vacuum beneath the piston in equal to about 11 lbs. per square inch for the greater part of the down stroke. The governor does not act, as is usual, by increasing or decreasing the power of each stroke, but by varying the number of strokes, each being of the same power. This is done without materially changing the speed of the shaft. Three or four explosions per minute are generally sufficient to turn the engine itself, and as a maximum of 30 to 35 may be made, there is a balance of, say, from 26 to 32 strokes or explosions per minute left to be applied to useful work under the regulation of the governor. As this engine can be started and stopped at a moment's notice, giving full power at once, and is free from the risks of a boiler explosion, it is peculiarly suited for use as a motor in a laboratory. The consumption of gas is seldom over 2*s*. 6*d*. worth per week for a 1-HP. engine. The engine as here exhibited contains many quite recent and very important improvements.

1946. Sectional Model of a **Steam Engine,** with expansion. *Paul Lochmann, Zeitz.*

1947. Sectional Model of a **Locomotive.** *Paul Lochmann, Zeitz.*

1948. Wall-diagrams illustrating the **Hot-air Engine.** *Prof. von Gizycki, Aix la Chapelle.*

1949. Wall-diagrams illustrating the **Gas Engine.** *Prof. von Gizycki, Aix la Chapelle.*

1950. Wall-diagram illustrating the **Steam Engine,** with continuous expansion. *Prof. von Gizycki, Aix la Chapelle.*

These diagrams are used in Prof. von Gizycki's lectures on description and theory of machines.

1951. Turbine to act as prime mover for physical laboratories. Head of water necessary, 10–20 met.; measure of water, 1 lit. per sec.; effective power about 10 meterkilo. *Prof. Wüllner, Aix la Chapelle.*

This turbine, with constant water pressure, is exceedingly steady in its action, and thus is specially suited for apparatus that require a constant velocity of rotation. With the fall of 18 mètres available in air, and a water supply of about one litre per second, the effect of the machine is equivalent to one man's power.

1952. Working Model, on a 1¼ inch to 1 foot scale, of a four wheel locomotive engine. Built at Alexandria in 1862 for service of Egyptian Railway between Alexandria and Suez. Jeffrey Bey, C.E., Great George Street, Westminster. *South Kensington Museum.*

Note.—The model represents an engine of the outside-cylinder "Stephenson" type, on four wheels, and is a tank engine of a peculiar form.

The water tank is hung beneath the boiler, the coal boxes are placed over the [illegible] of the boiler.

[illegible] are attached the necessary accessories of a locomotive engine, viz., [illegible] jack with traverser, screw keys, fire bars, lights, stoking irons, [illegible] etc.

1953. Model, in wood and brass. Sectional working model of [illegible]er, piston, slide-valve, eccentrics, link motion, and ot[illegible] Jeffrey Bey, C.E., Great Ge[illegible]et, *South Kensington Museum.*

Note.—This model also [illegible] [va]riable expansion and cut-off of steam in the engine cylinder.

1954. Drawing, on a scale [illegible]-inch to 1 foot, of a patent horizontal high-pressure conde[illegible] steam engine; designed and made by the Reading Iron Wor[illegible] Reading Iron Works Co., Limited, Reading. *South Kensington Museum.*

Note.—This drawing shows a side [illegible]tion of the engine and a through plan.

It represents an engine of 25 horse-p[illegible] nominal; having variable expansion gear, fly wheel, governor, feed pum[illegible] [an]d condenser.

A similar engine was employed to drive a part of the British machinery in motion at the Vienna Universal Exhibition for 1873.

1955. Photographs, two, of a compound horizontal-cylinder condensing steam engine. Constructed by the donors in 1873. 120 indicated horse-power. W. and J. Galloway and Sons, Engineers, Knott Mill Iron Works, Manchester.

South Kensington Museum.

Note.—One photographic view is of the cylinder end of the engine; the other shows the fly-wheel, crank shaft, and governor motion, &c.

The high-pressure cylinder is 14 inches in diameter. The low pressure cylinder is 24 inches in diameter. The stroke of the piston is 2 feet 6 inches.

This engine was employed in driving a portion of the British machinery in motion at the Vienna Universal Exhibition of 1873.

1956. Photograph of Brotherhood's patent three-cylinder high-pressure steam engine, arranged as a stationary engine. The engine was designed and patented by Mr. P. Brotherhood in 1872–73. Brotherhood and Hardingham, Engineers, London.

South Kensington Museum.

1956a. Model of **Brotherhood's** patent **Three-cylinder Hydraulic engine** arranged for turning a capstan, the pressure being supplied to the engine by a Brotherhood's patent three-cylinder pump. *Hydraulic Engineering Company, Limited, Chester.*

1957. Working Model of a stationary steam engine.

Royal Trade School, Halle (Director, Dr. Kohlmann).

1957a. Model of Goods Locomotive.

Museum of the Technological Institute, St. Petersburg.

1959. Two Hydrostatic Rotary Engines with table to which eccentric motion is conveyed. The machines were invented by the exhibitor for the purpose of facilitating the solution, aggregation, or precipitation of chemical compounds, which they do as effectually in half an hour as if the solutions were allowed to stand for 24 hours (tested by quantitative experiments). The table is open in the centre, so that a beaker or flask may be heated by a Bunsen burner, and it is furnished with double-sliding clamps so as to securely hold the vessel in its place.

A, engine intended for delicate quantitative experiments.

B, engine for ordinary purposes.

Joseph William Thomas, Cardiff.

1960. Working Model of Atmospheric Engine, with sun and planet motion. *Glasgow Mechanics' Institution.*

1963. Model of a patent direct acting "Universal" steam pump, as used for pumping water from mines, or for other purposes where simplicity of construction and economy of space are matters of importance. *Hayward Tyler & Co.*

1964. Drawing showing a longitudinal and a cross section through the steam cylinder of "Universal" steam pump, showing steam piston with slide valve therein, and the arrangement of ports. *Hayward Tyler & Co.*

1965. Wood Model to show the action of a recent improvement in the mechanism of the "Universal" steam pump for high "lifts;" the slide valve being contained in a valve chest outside the cylinder, and allowing of the use of an ordinary steam piston, thus allowing a longer stroke without lengthening the cylinder. *Hayward Tyler & Co.*

1966. Drawing illustrative of the arrangement of slide valve, &c. for the "long stroke" "Universal" steam pump for high lifts. *Hayward Tyler & Co.*

1967. Model of horizontal engine (novel girder pattern), with portion of cylinder removable to show the action of a variable automatic expansion valve gear (Rider's patent), controlled directly by the governor. The expansion valve works on the back of the lower valve by a separate eccentric in the ordinary manner, but owing to its triangular shape, and the form of the parts, the point of cut-off changes according to the angular motion of the valve round its spindle. This angular rotation is produced by the rise and fall of the governors through rack and quadrant. Any acceleration in speed thus affects the rise and fall of the governor balls, and accelerates or delays the time of steam admission.

Hayward Tyler & Co.

1967a. Pumping Machinery (being largely used for raising fluids, and the engine used as a prime mover.)

Hayward Tyler and Co.

In the pumping machinery, Nos. 1967a and 1963, great simplicity of construction and durability of parts. In Nos. 1964 and 1965, combined with the above is also the obtaining a longer stroke, means of starting from the outside by a lever, and the obtaining of a "rest" at each end of the stroke to allow time for the pump valves to close easily.

1968. Bailey's [illegible] **mple Engine House Recorder** registers [illegible] hich is removed, examined, and replaced every [illegible] rying pressure of the boiler and speed of the [illegible] time. It consists of a steam pressure gauge, a [illegible] ary [illegible] licator which registers on the diagram round the revolving d [illegible] n eight-day timepiece which actuates the drum and indicat [illegible] time, and a thermometer, all complete in French polished mah [illegible] any case, with closet for the safe keeping of tools, scientific i [illegible] nents, &c.

[illegible] *. Bailey & Co., Manchester.*

1968a. Model of a Steam E [illegible] **gine with Glass Cylinders,** for demonstration, 1852. *M. Eugène Bourdon, Paris.*

1978. Holt's Automatic Cylinder Drain Valves.

The object of this is to let out condensed or priming water from steam-engine cylinders. The valves open automatically at each exhaust, or when the engine stands, and remain open until the admission of steam, when they close, and prevent waste of steam.

Henry S. Holt, C.E., Leeds.

1979. Model of Dawes' Balanced Slide Valve.

The peculiar advantage of this consists in the mode of making an elastic joint between the relief frame and back of valve by means of a steel plate, secured to both in such a manner as to form practically one piece, thus avoiding leakage and the necessity of frequent attention. *Henry S. Holt, C.E., Leeds.*

1981. Model of Robey and Co's. semi-portable mining and winding engine. Richardson's patent. Robey and Co., Lincoln.

South Kensington Museum.

1982. McCarter's Patent Condenser, applicable to steam engines, and other purposes where a vacuum is required by the condensation of steam, without an air-pump being applied, and drawing its own injection water. *J. Wood.*

The condenser consists of two chambers, one above the other. The upper chamber (H) is for condensing the steam, the lower one (G), with the two tappet valves (C and D) opening into it, removes the condensed water from the upper chamber into the hot water cistern, whence it flows away.

The exhaust steam from engine enters at A, meets the injection water

entering at B, and is condensed, thus forming a vacuum, the water falling to the bottom of chamber (H). To remove this water, a vacuum is alternately created and destroyed, six times per minute only, in the lower chamber (G), by alternately raising the steam or water tappet valve (the steam supplying the tappet valve being reduced by reducing valve to 2½ lbs. pressure). On vacuum being created in lower chamber, the water collected in upper chamber is drawn down through india-rubber foot valve (E); and on vacuum being destroyed in lower chamber, the water falls out through the delivering valve (F) into waste water cistern.

1983. Fourneyron Turbine, ⅛th scale, by M. Clair.
Conservatoire des Arts et Métiers, Paris.

1990. Working Model of Whitelaw and Stirrat's Patent Water-Mill Turbine. *Glasgow Mechanics' Institution.*

The water-mill acts on a principle similar to that of the well-known "Barker's mill," but the arms are bent, and otherwise shaped, so as to allow the water to run from the central opening out to the jet-pipes.

1991. Working Models of three sets of Waterwheels, viz., undershot wheel, overshot wheel, and breast wheel.
Glasgow Mechanics' Institution.

1992. Model of Watt's Steam Engine.

1993. Model of the High-pressure Engine.
Prof. Meidinger, Carlsruhe.

The models are made of sheet-metal on pasteboard, are very durable, and show very clearly the relations of valve motion to piston motion.

IV.—RESERVOIRS OF ENERGY.

1994. The **First Hydraulic Press** ever made. Patented by Joseph Bramah, A.D. 1795, No. 2,045.
Lent from the Patent Office Museum by the Commissioners of Patents.

1995. Weisbach's Apparatus, for illustrating experimentally the laws of **Hydraulics,** and for the determination of hydraulic co-efficients. Large reservoir for the attachment of mouth-pieces and orifices under different heads. Gauging vessel. Smaller reservoir for the attachment of notches and open channels. Length of open channel. Collection of orifices, notches, mouth-pieces, &c. *Lieut.-Col. Chesney.*

Boilers, Injectors, Pressure Gauges, etc.

1969. Drawing, water-colour, on a ½-inch to 1 foot scale. A pair of double flue tubular Cornish boilers for high-pressure. Adamson's patent. D. Adamson & Co., Engineers, Hyde Junction, Manchester. *South Kensington Museum.*

Note.—Two of these boilers were lent to H.M.'s Commissioners for the Vienna Universal Exhibition of 1873, for use in supplying steam to drive the British machinery exhibited in motion.

The drawing shows front or firing and elevation of boilers; longitudinal elevation with brick setting.

Longitudinal sectional elevation, showing arrangement of flues; blow-off, feed, and other pipes. Brick settings.

Two cross sections.—One through centre of boilers; the other through back end, showing brick setting, flues, &c.

1970. Secti [illegible], showing the tubular arrangement, water sp[illegible] [illegible] Richardson's patent vertical high-pressure steam boiler. [illegible] & Co., Limited, Engineers, Lincoln. *South Kensington Museum.*

1971. Drawing of [illegible] patent vertical high-pressure tubular steam boiler. [illegible] Co., makers. Robey & Co., Limited, Engineers, Lincoln. *South Kensington Museum.*

Note.—The drawing shows a [illegible] elevation indicating the water circulation and the direction of the [illegible] products of combustion. Also a sectional plan of the boiler.

1972. Drawing, on a ¾-inch to 1-foot scale, of Howard's patent tubular safety land boiler; for high-pressure. J. and F. Howard, Engineers, Bedford. *South Kensington Museum.*

Note.—The drawing illustrates a front view of the boiler; longitudinal through section and plan. A cross section.

On a scale of ¼ full size is shown the detail of the water tube connexions.

These boilers are made by the Barrow-in-Furness Ship-building Company.

1973. Drawing, on a 1½-inch to 1-foot scale, of Messrs. A. Chaplin & Co.'s patent vertical tubular high-pressure steam boiler. Alexander Chaplin & Co., Engineers, Glasgow. *South Kensington Museum.*

Note.—The drawing shows vertical through sections. Two plans of the disposition of the upper and lower tubes.

1974. Drawing, sectional, on a 3-inch to 1-foot scale, of an improved vertical high-pressure steam boiler, having horizontal water tubes with "Nozzle" ends, to assist the water circulation. From the construction of the tubes with Nozzle ends this boiler is called the "Nozzle" boiler. Reading Iron Works Company, Limited, Reading. *South Kensington Museum.*

Note.—The drawing shows a through sectional elevation of the boiler, and a sectional plan of the arrangement of the tubes; the circulation of the water, together with the direction of the fire and products of combustion. Scale 3 inches to 1 foot.

1975. Steam Pump. Horizontal direct-acting steam engine and pump for feeding steam boilers with water, or for pumping

and draining purposes. Cope and Maxwell's Patent. Hayward Tyler and Co., 84, Whitecross Street, E.C.

The steam cylinder is 5 inches in diameter. The stroke is 7 inches.

The pump plunger is 3 inches in diameter.

The valves are balls of india-rubber.

The pump will raise 2,000 gallons per hour, forcing 120 feet vertically. *South Kensington Museum.*

1976. Three Models, in brass, showing in section the arrangement of Giffard's patent injector for feeding steam boilers with water. Sharp, Stewart, and Co., Engineers, Manchester, and Victoria Street, S.W.

a. Giffard's own patent injector in section.

b. Giffard's injector in section, with the patent adjustment of Messrs. Robinson and Gresham.

c. Giffard's injector in section, with Seller's patent adjustment. *South Kensington Museum.*

1977. Accessories.—Pressure Gauges, for Engines, Boilers, &c. Schäffer and Budenberg, 23, Lower King Street, Manchester.

a. A 5-inch Pearson's patent lubricator for steam cylinders, and other working parts of machinery.

b. Mercury vacuum gauge for condensing steam engines.

c. Thermometer for measuring high temperatures.

d. Bourdon's patent steam-pressure gauges, for high and low pressure boilers.

e. Bourdon's patent vacuum gauges.

f. Schäffer's patent steam-pressure gauges for high and low pressure boilers. Two of these gauges are in section showing interior arrangement.

g. Schäffer's patent vacuum gauges, for condensing steam engines, &c.

h. Schäffer's patent hydraulic-pressure gauges, with maximum indicators.

i. Blast furnace gauge, mercury; indicating 6 lbs. pressure.

k. 7-figure counter, in section, for counting steam engine revolutions and speeds of machinery. *South Kensington Museum.*

1996. Working Model of a Hydraulic Ram, arranged with glass air vessels, so as to show the action of a column of air and pulsations of delivery valve. *K. W. Hedges & Co.*

This ram will raise one gallon of water per minute 8 ft. high by use of four gallons of water falling 2 ft.

V.—REGULATORS.

1997. Spherical Governor for Steam Engines. I
by John Bourne.

Lent from the Patent Office Museum by the Commi
of Patents.

1998. Governor for Steam Engine. *Gro*

1998a. Gyrometric Governor for Steam Engin
Messrs. Siemens E

It consists of an open cup of parabolic shape, fixed upon a vertica
and caused to revolve within the closed chamber containing the l
bottom of the cup being open and always immersed below the surfa
liquid When the cup is made to revolve rapidly, the liquid conta
rises round the sides of the cup and sinks in the centre, the surfa
liquid assuming the inverted parabolic form ; and on reaching the ed
cup it overflows into the surrounding chamber, while at the sam
fresh supply of liquid is drawn into the cup through the openi
bottom ; and the power absorbed in putting the overflowing li
motion offers a continuous resistance to the rotation of the cup. C
with the edge of the cup, a series of fixed vanes are placed round
cumference of the external chamber, and a corresponding set of bl
also fixed round the outside of the cup just below the rim, so that
of liquid overflowing from the edge of the revolving cup is thrown ag
vanes, and by these is thrown back against the blades on the cup,
the overflowing liquid is made to offer an additional resistance to th
of the cup.

The internal radial arms uniting the shell of the cup to the ce
serve to communicate the rotary motion to the liquid inside the c
the bottom of the external chamber is provided with a number of ra
for the purpose of checking rotary motion in the liquid outside the c

So long as the cup is driven at a constant speed, the overflow is
and produces an absolutely constant resistance ; and, hence, if th
driven by a constant driving power, independent of the engine, its
as uniform as that of a chronometer, within a very small margin of v
which is definitely fixed ; and it continues revolving at an unchangin
totally independent of the engine, and consequently affords the r
forming a governor for controlling the speed of the engine to a co
uniform rate.

1999. Model of Holt's Injection Water Regulat

This is an automatic valve for regulating the supply of in
water admitted into steam-engine condensers, according
requirements of the vacuum. It is useful in engines h
very variable load, and where water is taken from town's
works for condensation. *Henry S. Holt, C.E.,*

1999a. Series of **Models** of **Governors,** &c. for
Engines, invented by Thomas Silver, of Philadelphia.

a. Differential marine governor.
b. Method of adjusting pneumatic governors when in motion.
c. Marine governor.

d. Combined isochronal and centrifugal governor.
e. Model showing T. Silver's earliest attempts at combining centrifugal and isochronal principle in his marine governor.
f. Reversible link motion.
g. Method of equalising the tension of a spring when in action.
h. Marine governor.
i. Marine governor.

2000. Model showing the effect of hanging the **Arms** of a **Governor** from different points with respect to the axis of rotation. *Jeremiah Head, M.Inst.C.E.*

By turning the horizontal sheave upon the model with gradually increasing velocity, it will be seen that the cross-armed, or approximately parabolic governor, goes through its range with the least variation of speed. Next in efficiency is that wherein the arms are hung from the central axis, whilst the very common form wherein the arms are hung externally is the least efficient, or, in other words, permits the greatest variation in speed between fully opening and fully closing the throttle-valve.

2001. Drawing, half the actual size, of a **Regulator** for a **25 Horse-power Boiler.** *M. Cleuet, Paris.*

This appliance is fixed to the inside of the furnace with an inclination of a few centimetres, in such a manner that the plane of the water level proper to be maintained passes through the upper tube at a point about half its length.

Connected with the boiler, on one hand, and with the feed pipe on the other, this appliance constitutes a kind of weight thermometer, the expansion and contraction of which depend upon the position of the water level in the boiler, and determine the flow by a discharge of the excess of water injected by the feed pump, which works uninterruptedly.

495. Rack and Snail of Clock, to regulate the number of blows struck each hour. *Council of King's College, London.*

496. Model of Chronometer Escapement.
Council of King's College, London.

497. Model of Lever Escapement.
Council of King's College, London.

498. Model of Horizontal Escapement.
Council of King's College, London.

499. Model of Locking Plate of Clock, to regulate the number of blows struck each hour.
Council of King's College, London.

2010. Gyrograph. *Prof. von Gizycki, Aix-la-Chapelle.*

This instrument serves in investigating the degree of inequality in the velocity of rotation of machine-shafts. The paper drum has rotation and axial velocity. The vertical deflections of the pencil from its lowest position are proportional to the increase of angular velocity of the shaft under examination. The instrument is driven by the latter by means of disc and cord.

2020a. Complete Working Model of the most Improved Form of London Brigade Steam Fire Engine, as now in daily use in the metropolis, constructed entirely by H. Nagy Effendi, Egyptian Government Pupil in the establishment of Shand, Mason, & Co. *Shand, Mason, & Co., London.*

2020b. Complete Working Model of the most Improved Form of London Brigade Manual Fire Engine, as in daily use in the metropolis. *Shand, Mason, & Co., London.*

2021. Machine for **Winding Cotton** into **Balls.** Invented by Sir Marc Isambard Brunel in 1802.

Lent from the Patent Office Museum by the Commissioners of Patents.

By the invention of this machine the use of cotton for sewing became universal, as before its invention linen thread or occasionally cotton, always in skeins, had been used.

2022. Model of **Machine** for **Carving Wood** and other **Materials.** Patented by Thomas Brown Jordan, A.D. 1845, February 17th, No. 10,523.

Lent from the Patent Office Museum by the Commissioners of Patents.

2025. The first **Machine** constructed for **Printing** and **Numbering Railway Tickets.** Invented and patented by Thomas Edmondson.

Lent from the Patent Office Museum by the Commissioners of Patents.

2031. Model of **Vauloue's Pile-driving Machine,** made by Jas. Ferguson, Esq., F.R.S. (the astronomer).

Bennet Woodcroft, Esq., F.R.S.

Vauloue's engine was used for driving the piles of old Westminster Bridge in 1739 and following years.

2113. Working Model of a steam pile-driving engine for submarine foundations, and other work. Sissons and White's patent. Sissons and White, Hull. *South Kensington Museum.*

Note.—This model, on about ½-inch scale, is a complete working illustration of a steam pile-driver. The winch to raise the monkey by an endless chain is driven by frictional gearing by the engine, which represents a high-pressure inverted-cylinder direct-acting engine, having slide valve, eccentric, flywheel, and force pump for feeding the boiler with water. The boiler represents an upright tubular boiler for working at high pressure.

2026. Model of **Large Shears.** Constructed by Messrs. Day and Co., of Southampton, for the Government Dockyards.

Lent from the Patent Office Museum by the Commissioners of Patents.

1960. Model of Dawes' and Holt's Hydraulic Shears.

In order to avoid buckling or bending either half of plate cut in two, a strip of metal equal to the thickness of the plate is sheared out of the plate, and the gap thus formed is utilized to allow the plate to pass the tie connecting the upper and lower blades; this machine can thus cut any size of plate.

Henry S. Holt, C.E., Leeds.

2027. Model of a W[illegible] **Lift.** Patented by Thomas Silver in 1872. The [illegible] his invention is applicable to ascending gradients.

Lent from the Pat[illegible] Museum by the Commissioners of Patents.

2027a. Model of Spout u[illegible] in Sunderland Docks for loading vessels with coals.

River W[illegible] Commissioners, Sunderland.

2027b. Model of Loading Drops used in Sunderland Docks for loading steam colliers [illegible] coals.

River W[illegible] Commissioners, Sunderland.

2027c. Model of **Apparatus** for **raising Heavy Spherical Bodies.** *Bennet Woodcroft, Esq., F.R.S.*

2028. The **Original Traversing Lifting Jack.** Patented by George England in 1839.

Lent from the Patent Office Museum by the Commissioners of Patents.

2029. Four methods of **converting Rectilinear** into **Circular Motion.**

Lent from the Patent Office Museum by the Commissioners of Patents.

2030. Bar Lathe used by James Watt.

Bennet Woodcroft, Esq., F.R.S.

2030a. Circular Rest, for turning spheres nearly up to the full diameter of the lathe. The Rest being also adapted for holding all kinds of plain tools or the "drill," "universal," and "eccentric" "cutting frames," &c., with overhead motion.

Tyssen [illegible]

2030b. Spherical Chuck (with six extra c[illegible] finishing spheres and chucking them for ornamental purposes. Invented by the exhibitor. *Tyssen Amherst.*

2030c. Specimen in ivory turned by the above apparatus, consisting of a series of spheres detached one within the other, in Chinese fashion. *Tyssen Amherst.*

2032. Instrument for **dividing** and **ruling** the **Brass Meridian Rings** of **Globes,** made by Jas. Ferguson, Esq., F.R.S. (the astronomer). *Bennet Woodcroft, Esq., F.R.S.*

2036a. Grover's Patent Holdfast Washers for securing nuts of fish bolts, and all bolts in machinery exposed to vibration. *T. W. Grover, C.E.*

2037. Photograph and Model representing an Hydraulic Canal Lift at Anderton, in Cheshire, constructed by Messrs. Emmerson, Murgatroyd, & Co., of Stockport and Liverpool, for the trustees of the River Weaver navigation, under the superintendence of Mr. Edwin Clark and Mr. Sidengham Duer.

This lift affords an easy and expeditious means of transferring laden barges between the Trent and Mersey Canal, and the River Weaver, instead of the tedious and costly process, previously in use, of transhipping goods from one set of barges to another. The canal is on the top of a bank, and the river is 50 feet 4 inches below it. Two barges can be transferred from the river to the canal, and two others from the canal to the river, in eight minutes; whereas in a chain of locks, where the difference of level is the same, only half that work can be performed in an hour and a half. It is preeminently useful wherever water is scarce, as it only takes about one per cent. of the water from the upper level which is used by the chain of locks. The photograph is from the work itself, while the model is only intended to show how one of the troughs, having taken a depth of 6 inches water over its area from the upper level, descends to the river, and in doing so lifts the other one nearly to the level of the canal by means of a central vertical hydraulic ram under each of the troughs. The rest of the operation is performed by a small steam engine. It was opened for public traffic by the trustees of the Weaver in July last, and has been in constant and successful operation since that time. The whole apparatus and other works in connexion with it are fully described by the exhibitor, and its applicability for lifting large ships is discussed in the "Minutes of the Proceedings of the Institution of Civil Engineers."

Sidengham Duer, B.Sc.

2038. Somerville's Machine for charging and drawing gas retorts by steam power.

It is constructed to run along the floor of retort house in front of retorts upon a line of rails or tramway, and consists of a platform on wheels, upon which is fixed a boiler and engine, which propels it and gives motion to the various parts. On the same platform is erected an upright frame, which serves as a support to the cradle or secondary platform carrying the scoop for charging or filling, and the rake for drawing the retorts; on top of frame is a receptacle (over the scoop) which is supplied with coals from another receptacle below by means of an elevator or Archimedean screw, whereby the scoop is filled with coals. The rake is attached in a similar manner to the scoop, and is propelled and withdrawn in the same way.

John Somerville, Dublin.

2039. Model of a **Californian Stamping Mill.**

Royal Saxon Mining Academy, Freiberg.

Machine for **Engraving** duplicates of **Medallion** .**ure, &c.** (J. Bates' Patent, 1823.)

Bennet Woodcroft, Esq., F.R.

The object of this machine is to copy or engrave on metal plates an exac representation of medals, sculpture, and other works of art executed in relie

2044. Model of **Nasmyth's Direct Action Steam Ham mer.** (Nasmyth's Patent, 1842.)

Bennet Woodcroft, Esq., F.R.

2045. Drawing of a **50-to Double-action Steam Ham mer,** supplied to the Russian Government for their gun factory St. Petersburg. *Thwaites and Carbu*

Diameter of cylinder, six feet six inches; length of stroke, twelve feet inches, total height from ground line, fifty feet.

2045a. Model of a Friction-Hammer.

John Tille, Prague.

This model is 72 cm. high, 42 cm. broad, and 21 cm. in depth, and has been executed after the pattern of the friction-hammer constructed in the Royal Prussian Machine Workshops at Dirschau, where the exhibitor, in 1858 and 1859, was employed with the construction of the incline between Elbing and Osterrode.

With reference to this model it is to be observed that the small cog-wheels fixed on the revolving shafts of the friction-rollers have only been attached for the purpose of putting the model in motion with a crank.

2045b. Model of a Spring or Elastic Hammer.

John Tille, Prague.

These favourite spring-hammers, if in quick motion, effect a very powerful stroke; if in slow motion, a moderate stroke, the regulation of which is obtained by a treadle and a draw-pole, by means of a tension roller supported by levers. If the movement is stopped, the tension roller acts as a brake-weight

In recent times, spring-hammers of this form are manufactured by Messrs. Auth, Fetu, and Deliege, at Liége.

2045c. Model of a Punching Machine, with contrivance of extramission. *John Tille, Prague.*

This model is constructed after Borsig's pattern, in which the balancing punch is moved forwards by a crank and wheels, by means of a movable press-bar.

2045d. Model of Parallel Shears. *John Tille, Prague.*

The movable cutting blade is fastened to a well regulated sliding piece, and moved by a crank and wheels by means of a draw-bar. This model is arranged at the same time to be worked by means of leather straps.

2045e. Model of Circular Shears, with cast ribbed frame.

John Tille, Prague.

2045f. Model of Circular Shears, with concave cast frame.
John Tille, Prague.

These two models, the circular cutting blades of which are fastened on spindles, and put in motion by means of wheels and cranks, illustrate chiefly the solidity and elegance of the concave casting as compared with the ribbed casting.

2046. Circular Knitting Machine. (J. A. Tielen's Patent, 1842.) *Bennet Woodcroft, Esq., F.R.S.*

2047. Models of **Chinese Agricultural Implements** (9), small mill, &c. *Bennet Woodcroft, Esq., F.R.S.*

2048. Model for showing the **Curves** of **Screws.**
Bennet Woodcroft, Esq., F.R.S.

2050. Traction Dynamometer, used for ascertaining the draught of carts, waggons, and all agricultural implements that are drawn by horses. Also, for determining the resistance of roads and streets. *Royal Agricultural Society of England.*

The instrument is harnessed just like a horse to the implement it is desired to test, and being itself drawn along by one or more horses it registers the total work done in passing over any given distance, the mean and extreme tractive force, the pressure on the back of the horse, and the lateral pressure in such implements as reaping and mowing machines. First used at Bedford, 1874. Designed and made for the society by its consulting engineers. *See* Journal of the Royal Agricultural Society of England, No. XX., part 2, page 678.

2051. Appold Friction Dynamometer, of 100 horse-power, used for measuring the work done by steam engines and other prime movers. *Royal Agricultural Society of England.*

The prime mover to be tested is coupled to the main shaft of the dynamometer, the friction breaks of which are loaded in proportion to the power it is desired to develop. The instrument registers the number of revolutions made in a given time, and this, together with the known weight on the breaks, furnishes the data for calculating the work done by the prime mover. This powerful instrument was constructed by the consulting engineers of the society, for the trial of steam ploughing and traction engines at Wolverhampton in 1871.

2053. Pneumatic Pump, with taps. Invented by 'sGravesande. *Professor Dr. P. L. Rijke, Leyden.*

The taps are at each stroke of the piston turned 90° by an appliance in the form of a cross fixed to the handle. (*See* 'sGravesande's "Physices Elementa Mathematica," ed. III. vol. II., p. 591.)

2053a. Pneumatic Intercepting Apparatus for sending and receiving message carriers in pneumatic despatch tubes of 3 inches diameter, to be worked on the circuit system.
Messrs. Siemens Brothers.

2052. Diplograph. Writing machine for the **Blind,** by which writing in relief and ordinary writing are performed at the same time.

Ernest Recordon, Geneva.

2054. Dr. Thursfield's Patent Writing Frame, for enabling the Blind, and persons with defective or failing sight, to write; and for facilitating writing in darkness or an unsteady light.

Elliott Brothers.

By means of Dr Thursfield's [illegible]atus anyone can write with equal facility in light and da[illegible]se with defective or failing sight it is of the utmost value at al[illegible] used in ordinary daylight no writing is visible, and the involu[illegible]f the writing by the eye is prevented. In cases of incipient cataract, and o[illegible]phthalmic diseases requiring rest, or after operations on the eye, it has bee[illegible] found a most valuable therapeutic agent. To literary men, travellers by r[illegible]ilway or steamboat, and others compelled often to write in a bad or unste[illegible]ly light, the invention will prove of great service. No ink or pencil is requi[illegible]ed, but the writing is equally legible and indelible. The mode of using [illegible] apparatus is very simple, and where any sight remains will at once be co[illegible]hended and found easy of execution.

2054a. Peters's Machine for Microscopic Writing, combining Ibbetson's Geometric Chuck.

Royal Microscopical Society, London.

With this machine any combination of bicycloid curves can be produced on a scale wonderfully minute. Many beautiful and complex designs of this kind have been engraved on glass with remarkable precision, in the space of a circle the fiftieth of an inch in diameter.

A disc the one-hundredth of an inch in diameter appears to the unaided eye as a mere point, yet that point, not larger than the full-stop of ordinary print, will contain five circles each, the three-hundredth of an inch in diameter, and in a circle of that size (that is, about the size of a transverse section of a hair of the human head) the Lord's Prayer is written and can be read. It has also been legibly written in the three hundred and fifty-six thousandth part of an inch. In this specimen the writing is so small, that, in similar characters, the Bible and Testament together (said to contain 3,566,480 letters) could be written twenty-two times in the space of one English square inch.

The name and address of Mr. "Matthew Marshall, Bank of England," has been written in the two-and-a-half millionth part of a square inch.

2054b. Facsimile Drawing and Writing Apparatus.

G. F. Pichler, London.

2055. Apparatus for filling **Manometer Tubes** with **Mercury** to any height.

The Director of the Physical Laboratory of the University of Groningen.

The end of an india-rubber tube is screwed into an opening in the base of the manometer. A wooden vessel filled with mercury is elevated by means of a vertical iron rod to a height nearly corresponding with that desired in the manometer tubes. With the aid of a piece of wood, which is plunged into the wooden vessel, the exact adjustment of the mercury to the required height in the manometer can be effected.

2056. Diagrams illustrating the principles adopted in constructing **Wood-planing Machines.** These diagrams are used in lectures on Applied Mechanics at the I. and R. High School of Agriculture and Forestry, Vienna.

Dr. William Francis Exner, Vienna.

In the forestry section of the above school, series of lectures on the mechanical technology of wood-working are delivered annually. These are frequented by foresters who wish to become qualified for the post of manager of wood-working establishments. For these lectures diagrams of all sorts of tools and machinery for wood-working are prepared. The examples shown form only the first part of the series.

2057. Model of **Lever Plough, with 6 shares,** for ploughing by steam. (Fowler's system, reduced to one-tenth.)

M. Digeon, Paris.

2059. First Type-distributing Machine, invented by Alexander Mackie. *John Maclauchlan.*

2059a. Coining Machinery—A Cutting out or Punching Press, with self-acting feed and rollers for carrying the fillets.

Maudslay, Sons, and Field.

2060. Drawings of the air compressors on the Colladon system, employed in boring operations at the St. Gothard.

Professor Daniel Colladon, Geneva.

2061. Models, Twenty-seven, for teaching machinery, executed by M. Schröder, of Darmstadt. *Prof. Pigot, Dublin.*

PUMPS.

2062. Model of Force Pump.

Prof. W. F. Barrett, Dublin.

2063. Model of Ordinary Water Pump.

Prof. W. F. Barrett, Dublin.

1989. Model of Sand Pump.

Council of King's College, London.

1989a. Air Water Pump, by Jagn.

R. Nippe, St. Petersburg.

2064. Model (to scale) **of Centrifugal Pump.**

Lawrence and Porter.

This pump has been patented by Messrs. Lawrence and Porter. The chief feature of the patent is the arrangement of making one side of the casing removable. The advantages of this system are as follows: By taking off the movable side, the disc or "fan" can readily be examined or removed in a few minutes without in any way disturbing or interfering with the suction or delivery pipes. This is found in practice to be a very great advantage.

king the side removable the amount of both machine and hand ; up the pumps is greatly reduced. The size and weight of raise a given quantity of water) are considerably diminished, so that pumps made on this system are far more compact and portable than any centrifugal pumps of the ordinary construction.

One of Lawrence and Porter's pumps with discharge pipe six inches diameter, and weighing only $3\frac{1}{2}$ cwt., is capable of raising 900 gallons of water per minute, or 54,000 gallons of water per hour. Many of these pumps are now actually at work with highly satisfactory results, and they have received favourable notice by the scientific press.

N.B.—I[illegible] emoved by simply pulling it gently in a horizo[illegible] merely for show, and do not hold it on, and by loosening [illegible] he pulley the disc and spindle can be instantly withdrawn [illegible] exami[illegible] The patentees will be glad to give further information

2064a. Appold's Or[illegible] entrifugal Pump and Four trial Discs. *[illegible]cil of King's College, London.*

2066. Archimedean Scr[illegible] with glass screw to show the raising of the water. *Elliott Brothers.*

2065. Hook's Univers[illegible] [illegible]int, by which a shaft can be kept in rotation at any angle. *Elliott Brothers.*

2067. Steam Thermometer, for testing temperature of steam in the supply pipes. *Elliott Brothers.*

It consists of a thermometer the bulb of which dips into an iron cup containing mercury and oil. By this means the bulb is protected from breakage by pressure, and the thermometer can be removed at any time without letting off steam.

2068. Air Bell.

The Committee, Royal Museum, Peel Park, Salford.

An apparatus consisting of a metal tube 30 feet long, with a percussion pump at one end and a clapper at the other, which rings a bell whenever the piston is struck.—[Supposed to be the invention of the late Mr. Gavin M'Murdock, of Soho, Birmingham.] Made by the late Richard Roberts, C.E., of Manchester, 1840.

2069. Parallel Motion.

The Committee, Royal Museum, Peel Park, Salford.

Consisting of one wheel revolving within another of double its size, and carrying a pin whose centre, coinciding with the pitch line of the lesser wheel, traverses a straight line equal to the diameter of the larger.—[The invention of the late Mr. James White, of Manchester.] 1842.

2073. Apparatus for supposed **Perpetual Motion,** used by Dr. Thomas Young. *The Royal Institution of Great Britain.*

A wheel supposed to be capable of producing a perpetual motion, the descending balls acting at a greater distance from the centre, but being fewer in number than the ascending ones. "Lectures on Natural Philosophy," by Thomas Young, M.D., 1807.

2074. Model of Parallel Motion, consisting of three parts only, which owing to the relative positions of the fixed centres and joints is not liable to lateral deviation in practice.

William Hayden.

2075. Parallel Motion; invented by the late Richard Roberts, C.E., Manchester; the peculiarity consists in the fixed centres being in the plane of the parallelism.

The Committee, Royal Museum, Peel Park, Salford.

2076. McKay's patent Equilibrium **Drilling Tools,** with specimens of work. *Menzies & Blagburn.*

This apparatus is designed to permit circular holes of any size to be bored out with mathematical accuracy and absolute precision as to their relative positions.

This object is attained by maintaining the centre point, around which the cutters revolve, immovably fixed during the process of boring, while the cutters are advanced, and are held in equilibrium with the centre points by a hydraulic medium contained within the chambers of the tool, the pressure being conveyed by the action of the feed given to the boring machine.

This apparatus is exhibited for the purpose of showing how accurate work can be obtained with a minimum of skilled labour and cost.

2076a. Isometric Drawing of an Expanding Mandril, or tool for fixing the tubes in the plates of boilers by expanding the ends so that the tubes are firmly fixed in their places.

W. H. Prosser.

Invented and made by the late Richard Prosser of Birmingham in 1845.

Two of these expanders were sent to the United States in 1847; an improvement on them is now being imported from that country.

2077. Bates' Anaglyptograph. Machine for producing drawings or etchings in relief from models, coins, medals, &c.

George Hogarth Makins.

The machine consists of two portions:—The first a solidly framed oblong base, in which is fixed a long double screw, right-handed at one and left-handed at the other half, and of 20 threads per inch; rotation of this gives opposite motion to two tables, upon the front one of which the object to be copied is fixed, and upon the other the plate to receive the etching or drawing. At the winch end of the screw is fixed a wheel cut with 100 teeth, and also a stop arrangement by which any number of the teeth can be taken, and thus equal partial turns given to the screw.

The second portion of the machine is a framed apparatus carrying the tracing and etching points. This is provided with wheels for travelling across the base, and a groove is formed in the latter for their direction. The tracing point is attached to a bar which in rising does so at an angle of 45°. In the centre of the bar is a piece which, being between friction wheels attached to the diamond or etching point frame, will, as the bar rises by passing over any elevation in the object, cause the diamond frame to move at right angles to the motion of the machine, and thus the line forming is curved or waved just in proportion to the height of the elevation passed over; hence the appearance of relief given to the etching.

2105. Model of a power weaving loom, showing arrangement for working a double shuttle-box, and other features. Designed about 1840. *South Kensington Museum.*

2106. Model of power weaving loom, with Jacquard arrangement attached, for weaving or working figured stuffs or pattern stuffs. *South Kensington Museum.*

This model shows the arrangement of the cards in the loom after they have been cut for the desired pattern to be worked. It further illustrates the general movement of the several parts of a Jacquard loom.

2106a. Model of **Power** [illegible] **oom** constructed to show the ordinary manner of working [illegible] am and Taylor's patent method of performing the same.

Lent from the Patent Office Museum by the Commissioners of Patents.

2106b. Improved Jacquard Apparatus and **Fittings,** worked by pegs. *Bennet Woodcroft, Esq., F.R.S.*

In this improved Jacquard apparatus, those warp threads which are not raised to form the shed or opening for the shuttle to pass through and deposit a weft thread are depressed to the same extent that the others are raised. (Woodcroft's Patent, 1838.)

2106c. Full-size **Section Tappet** for **Looms,** for weaving a variety of patterns. *Bennet Woodcroft, Esq., F.R.S.*

2106d. Model of **Loom,** with improved tappet plates and jacquard apparatus. (Woodcroft's Patent, 1838.)

Bennet Woodcroft, Esq., F.R.S.

2106e. Mule for **Spinning Cotton** and other fibrous substances. (Jas. Smith's Patent, 1833.)

Bennet Woodcroft, Esq., F.R.S.

2106f. Improved Jacquard Machine worked by paper cards. *Bennet Woodcroft, Esq., F.R.S.*

The improvement in the jacquard machine consists in its being so constructed and worked as to depress some of the warp threads as much as it elevates others, whereas in the machine invented by Jacquard, and called after him, none of the warp threads were depressed, the opening for the shuttle being made by elevating some of the warp threads only. (B. Woodcroft's Patent, 1838.)

2106g. Steam Power-loom. *Bennet Woodcroft, Esq., F.R.S.*

2107. Model of a hand loom, for weaving sacks, hop pockets, &c. This loom is designed to weave sacks or pockets without a seam either at the sides or end. Invented by T. Clulow.

South Kensington Museum.

2108. Model of a hand loom for weaving fishing nets. G. Roberts, inventor. *South Kensington Museum.*

2109. Model, on a ⅓rd scale, of a plain and fancy goods weaving loom, having 12-inch reed space. The model can be driven either by hand or power. Robert Hall, Bury, Lancashire.
South Kensington Museum.

2110. Model, on ⅓rd scale, of a plain and fancy goods weaving loom, having 12-inch reed space. The model is arranged to be driven by power. Savill and Woolstenhulme, machine makers, Oldham. *South Kensington Museum.*

2111. Series of Temples (20 in number), of various sizes. Used in power looms for stretching the woven cloth. The temples are self-acting, and are suitable for woollen, cotton, and other heavy or light fabrics. R. Hall, Hope Foundry, Bury, Lancashire. *South Kensington Museum.*

2112. Drawing of patent machinery for preparing chemically pulp from wood, straw, and fibrous material for the manufacture of paper of all kinds and qualities. Sinclair's system. J. McNicol, C.E., 97, Buchanan Street, Glasgow.
South Kensington Museum.

Note.—The drawing represents the following portions of the patent machinery by W. Sinclair, for paper manufacture.

On a ½-inch to 1 foot scale :—

Fig. 1. Longitudinal through section of Sinclair's patent high-pressure tubular steam boiler.

Fig. 2. Front or firing end elevation of Sinclair's high-pressure tubular steam boiler.

Fig. 3. Sectional elevation of wood-pulp boiler.

Fig. 4. End elevation of blow-off pulp receiving tank.

Fig. 5. General plan of apparatus.

Fig. 6. Front and side elevation of wood-chopping machine.

Fig. 7. On a scale of ¼ inch to 1 foot. The soda ash (used to dissolve the wood into pulp) recovery apparatus. A longitudinal and cross section of the apparatus.

Fig. 8. On a full size scale. The Sinclair's patent conical plug joint for high-pressure steam boiler tubes.

Fig. 9. On a full size scale. The section of a hollow conical boiler tube joint. Sinclair's system.

2114. Working Drawing, on a ⅓ scale, or 4 inches to 1 foot.
Sheave or pulley. For a hoisting crane.
Side and end elevations.
Two through sections.
South Kensington Museum.

2115. Working Drawing, on a ½ size scale, or 6 inches to 1 foot.
Spur wheel. Tooth wheel for gearing.
Side elevation, showing method of laying out pitch of tooth and tooth circle.
Section of arm of wheel.

rough centre of wheel.
wheel. *South Kensington Museum.*

2116. Working Drawing, on a $\frac{1}{3}$ scale, or 4 inches to 1 foot.
Mitre wheel, gear wheel. Showing plan, elevation, and sections of wheel.

South Kensington Museum.

2117. Working Drawing, on $\frac{1}{12}$ scale, or 1 inch to 1 foot.
Eight feet cast-i
Side elevation section.
End elevation. se tions.

South Kensington Museum.

Note.—The wheel is cast in two nts, and united by wrought-iron hoops, shrunk on the boss, and by do ad cotters at the rim.

2118. Working Drawing, $\frac{1}{4}$ scale, or 3 inches to 1 foot.
Cast-iron engine crank.
Side elevation. Plan throu
Plan when turned $\frac{1}{4}$ of a re n.
Section through firm and web.
A longitudinal through section, and a section when turned $\frac{1}{4}$ of a revolution.

South Kensington Museum.

2119. Working Drawing, on a $\frac{1}{3}$ scale, or 4 inches to 1 foot.
Connecting rod end, for a 25 horse-power steam engine.
Elevation. Plan. Two sections.

South Kensington Museum.

2120. Working Drawing, of the governor of a steam engine.
Front and side elevation.
Elevation and plan of slide.
Pendulum rod, showing ball in section, and method of attachment.
Elevation and plan of forked rod.
Section through slide.
The front and side elevations are on $\frac{1}{4}$ scale, or 3 inches to 1 foot.
The details are on $\frac{1}{2}$ scale, or 6 inches to 1 foot.

South Kensington Museum.

2121. Working Drawing, on a $\frac{1}{2}$ scale, or 6 inches to 1 foot.
Pillar block, plummer block, or *pedestal*; for a $4\frac{1}{2}$-inch shaft or journal.
Side elevation.
End elevation. Plan. Sheet No. 1.

South Kensington Museum.

2122. Working Drawing, on a $\frac{1}{2}$ scale, or 6 inches to 1 foot. Pillar or plummer block for a $4\frac{1}{4}$-inch shaft or journal.
Various sections. Sheet 2.

South Kensington Museum.

2123. Working Drawing, on a $\frac{1}{4}$ scale, or 3 inches to 1 foot. Hanging bracket and pillar block, for a $3\frac{1}{2}$-inch shaft; attached to a 16-inch cast-iron girder.
Front and side elevations. *South Kensington Museum.*

2124. Working Drawing, full size. Steam whistle.
Elevation. Plan. Sections.
The vertical section shows by arrows the passage of the steam through the whistle.

South Kensington Museum.

2125. Working Drawing, on a $\frac{1}{4}$ scale, or 3 inches to 1 foot. Movable head stock for a turning lathe.
Side elevation, plan, and section.
End elevation and section.

South Kensington Museum.

2126. Working Drawing, full size.
Water cock or tap.
Side elevation. End elevation.
Plan. Side and end elevation of plug.
Through section of tap.

South Kensington Museum.

2127. Working Drawing, on a $\frac{2}{3}$ scale, or 8 inches to 1 foot. Stop-cock or straightway cock, for steam or water.
End elevation. Side elevation. Plan. Two sections.
Fourteen working drawings (lithographs), parts of machinery and steam engines. Thomas Busbridge, Plumstead, S.E.

South Kensington Museum.

2127a. Machine for Originating Screws, with micrometer adjustment applied to tangent screw which sets the guide at any angle suitable to required pitch (adjustable to $\frac{1}{100}$ degree). The cutter is carried in sliding rest. Specimens of screws originated in machine. *Maudslay, Sons, and Field.*

2127aa. Machine for Originating Screws of any required pitch and diameter (by the late Mr. Henry Maudslay).

Maudslay, Sons, and Field.

Inside the cylindrical hole (below the table) is a steel knife edge which is attached to the divided circle (above). This circle and knife edge can be adjusted by a micrometer tangent screw to the calculated angle of the thread. The knife edge presses on and acts as a guide to a cylindrical rod passed through the

ho the required feed while the thread is cut by a small tool ca de rest seen at the side of the machine. The bar on which the screw be cut is carried in the centres of a lathe, while the screw machine is allowed to travel freely along the bed of the lathe. The bar is removed from the machine so as to enable the knife edge inside to be seen. When the circle and knife edge are set at the required angle they can be clamped to the frame. Date 1800–1805.

2127b. Three Guide Screws originated in the above machine; each screw contains 50 threads to the inch. The largest screw is $1\frac{1}{16}$ in. diamet 4 threads in the entire length. The nut for this screw side; it is 12 inches long and has 600 threads. *Maudslay, Sons, and Field.*

2127c. Hand Plane al, by the late Mr. Henry Maudslay. *Maudslay, Sons, and Field.*

2127d. A Metal Plough Moulding, by the late Henry Maudslay. *Maudslay, Sons, and Field.*

2127f. Original Screw g Lathe, made and used by the late Henry Maudslay. 8 change wheels, and sector frame for carrying an interm wheel for cutting left hand screws. Four guide screws are shown, 100 threads, 50 threads, 35 threads, 30 threads to the inch. Also a small cone chuck and hollow mandril, screw tools for slide rest, and the original working handle used by Mr. Maudslay, below the bed. Date 1800 to 1810.
Maudslay, Sons, and Field.

2127g. Skeleton Stocks and Dies, four sets, about 1805 to 1810, made and used by the late Henry Maudslay. The extreme delicacy and finish of the work are worthy of notice.
Maudslay, Sons, and Field.

2127h. Coining Machinery. A cutting-out press for blanks, with self-acting feed rolls to deliver fillet. Date about 1814.
Maudslay, Sons, and Field.

2135. Three Elliptical Guides.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2138. Elliptic Guide, with long radius bar.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2139. Approximate Elliptic Guide.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2140. Spur Wheel Gearing.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2142. Kinematic Pillar Vice, with triangular link-motion.
Royal Geological Institute and Mining Academy (*Director, Prof. Hauchecorne*), *Berlin.*

This stand is so arranged that any link of the kinematic chains can be fastened in it easily and securely, so that they can be shown in every possible position.

WHEEL GEARING.

2143a. Model of a Machine for Cutting the Teeth of Bevel Wheels. *F. Engel, Hamburg.*

In the usual cutting and planing machines for conical toothed wheels, each interstice between the teeth is produced by at least two operations; first one side of a tooth is shaped and planed, then the opposite side of the next tooth. The present machine cuts both profiles simultaneously with the same cutter. A lateral motion is communicated to the cutter, the axis of the tool oscillating about the cutting point of the conical surface, and working alternately the one and the other side of the tooth profile. The machine is more accurate than previous ones, and other kinds of wheel can be shaped with it.

2143b. Samples of Wheels which have been cut by the Machine. *F. Engel, Hamburg.*

2143c. Drawing of the Machine. *F. Engel, Hamburg.*

2144. Bevel-Wheel Gearing.
Royal Geological Institute and Mining Academy (*Director, Prof. Hauchecorne*), *Berlin.*

The models exhibited are a small portion of the collection used for machine-instruction in the Königlichen Berg-Akademie (Royal School of Mines). They have been made specially for this purpose by Herr Maiss, in the workshops of he Academy, upon the designs of Prof. Hörmann. The models of separate mechanisms have been constructed upon the principles laid down in Prof. Reuleaux's "Theoretische Kinematik"; they are all arranged for "inversion," that is, so that either of their links may be fixed in the screw stand exhibited with them, and the various properties and applications of the inversions easily shown.

The models are all made with the special view of illustrating in the most complete, clear, and simple manner the principles of the machines and mechanisms which they represent. All details not required in this relation are omitted or made subordinate, the parts which it is important for the students to observe are polished, the other parts, in order not to attract attention unnecessarily, are made a dead black, so that all disturbing reflections of the light are prevented. Care has been taken also to arrange them so that all essential parts and their combinations may be visible at a glance in all parts of the class-room, so that the alterations which it is necessary to make during the lectures may occupy a minimum of time, and altogether that teachers may find their use in demonstrations very convenient. In the steam-engine models it has also been endeavoured to make the relative dimensions and arrangements as far as possible to resemble those of actual practice.

2144a. A Pair of Worm Wheels, with parallel axes.
Royal Geological Institute and Mining Academy (*Director, Prof. Hauchecorne*), *Berlin.*

orm-Wheel, with inclined teeth.
... Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2144c. Annular Wheel and Pinion.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2144d. Hypocycloidal Gearing.
Royal Geological Institute and Mining Academy (Director, Prof. Haucheco

2144e. Worm-Whe ight teeth.
Royal Geological . Mining Academy (Director, Prof. Hauchecorn

2144f. Pair of Wo with axes at right angles.
Royal Geological ... Mining Academy (Director, Prof. Hauchecorne),

2144g. Skew Mitres.
The Committee, fuseum, Peel Park, Salford.

A pair of toothed mitre wheels l on shafts that cross each other. The invention of the late R. Roberts, of Manchester, 1836.

2144h. Intermittent Wheels.
The Committee, Royal Museum, Peel Park, Salford.

The larger wheel performs six revolutions for one of the lesser. The invention of the late R. Roberts, C.E., of Manchester.

2145. Model of Cugnot's Steam Carriage, 1783.
Conservatoire des Arts et Métiers, Paris.

2146. Model of a centrifugal smoke purifier.
Dr. Otto Braun, Berlin.

This model shows the action of centrifugal force on bodies suspended in gases, by means of it sparks, soot, tar, ammonia, &c. can be removed from smoke.

2146a. Tyndall's Smoke Filter Respirator, suitable for firemen, fire-escape men, and for persons entering deleterious atmospheres.
James Sinclair.

The filtration is by means of dry cotton wool, dipped in glycerine and charcoal.

2146b. Tyndall's Smoke Filter Respirator, combined with elastic tube, suitable for mining operations, chemical works, breweries, &c.
James Sinclair.

This respirator is designed to enable the wearer to enter and breathe freely in mephitic gases by means of the tube, which can be used in lengths up to 90 feet, the wearer being enabled to communicate verbally with those outside and they with him.

VII.—SHIPPING, NAVAL ARCHITECTURE, AND MARINE ENGINEERING.

2147. Models made of hard paraffin for ascertaining the **Resistance** of **Ships** by measuring the resistance of their models.

W. Froude, F.R.S.

The models from 6 to 16 feet in length are made of hard paraffin. The experimental apparatus employed in working the model includes appliances for designing, moulding, and casting the models, shaping them by automatic machinery, moving them through the water at the required speeds, and automatically recording the leading phenomena of the trial, namely, the speed, the resistance, and the change of level induced by the speed at each end of the model.

The several processes are illustrated by the accompanying series of seven photographs and two specimens, which may be explained as follows :—

No. 1. The designer.

This consists of a pile of adjustable templates, the thicknesses of which represent the horizontal intervals between the successive water-lines of the intended models shown on a reduced scale. One edge of each template is an elastic steel band held to a wooden base-piece by adjustable ordinates hinged to the band and sliding through mortices in the base-piece fitted with hinged metal clamps. One of these templates (No. 8) set up as for use is sent to aid this explanation.

The photograph shows them in combination, and represents the intended small scale model by a series of water-lines in steps, which, if either filled up solid and fair to the salient angle of each, or trimmed off fair to the re-entering angle, would constitute the finished form.

No. 2. *a*. The moulding box ; *b*. The mould ; and *c*. The core.

L. B. D.

a. A rectangular wooden box 16′ × 2′ 9″ × 1′ 10″.

In this the external form of the full sized model (that is (*b*) the mould) is aped by help of a series of rough cross sections deduced from the small scale signer, and into the mould is fitted the core (*c*), which constitutes the figure the inside of the model. *c* is framed on a series of internal cross sections le good to a surface and rendered coherent, first by a series of laths nailed to n externally, and, secondly, by a skin of calico drawn tight over the lathed ice, and then coated with plaster-of-paris and clay. Between this "core" the "mould" there is, of course, a space, equal to the intended thickness e model, into which space the melted paraffin is run, and there allowed main until by cooling it has become solid enough to bear removal.

s. 3 and 4, the shaping machine.

is is what has sometimes been termed in technical phrase a "copying ne." The model, bottom upwards, and adjusted successively to a series erent levels, travels longitudinally between a pair of revolving cutters, are caused by means of a hand lever to so recede and approach one r, as the model passes, as to cut upon the model the horizontal section ter-line," correctly appropriate to the level at which the model is set. side of the machine, in full view of the operator, there is a vertical which carries either a drawing of the intended model, showing the series -lines to be cut, or one of the "designer" templates already described. of this board is a "tracer," and the board and the "tracer" severally upon the appropriate scales (the former by longitudinal motion, the vertical motion) the longitudinal motion of the model and the lateral f the cutters. Thus the drawing (or template) passing along beneath is practically a small scale picture of the model travelling past the

... if the tracer be made to follow the correct line on the drawing (... the edge of the template) the revolving cutters will cut the ... line on the model.

The model is then finished by hand with spokeshaves and scrapers, an operation which takes a man about three hours.

No. 5 The hauling engine.

This is the instrument by which the required motion through the water at definite speed is given to the model. The dynamometric truck to which the model is attached is connected by a wire rope with a winding drum, driven by a ... ary double-cylinder steam engine. The engine is regulated by an ... sensitive governor, acting upon a delicate steam throttle valve, on ... principle, in which the governor rotates at its own ... pendently of the engine, the steam valve being open... s the engine is lagging behind the governor ...

By adj... rifugal ... the governor, with a right and left-handed ... differenti... the belt which connects it with the e... red speed ... signed to the engine between the limits ... and 850 reve... er minute, and by further changing the gear ... connecting the ... and winding drum, speeds varying from 60 to 1,200 feet per minu... be assigned to the dynamometric truck.

Nos. 6 and 7. The dynamomet... with model under it.*

The dynamometric truck runs ... ght and level railway about 200 feet in length, suspended over a waterway ... feet wide and 10 feet deep. The model floating in the water is as it were "harnessed" to the truck, and travels with it. It is kept from diverging sideways by a knee jointed frame or "guider" at each end, of such construction as to perfectly prevent the slightest sideways deviation of the model, but in no way to interfere with its rising or falling, or moving in a fore and aft direction with reference to the truck. The towing strain (*i.e.*, the force necessary to make the model accompany the truck in its longitudinal progress) is taken during the experiment by a spiral spring, the extension of which, measuring the towing force, is indicated on a large scale (through the intervention of certain levers) by a pen which makes a line on a recording cylinder covered with a sheet of paper. The recording cylinder is driven by the truck wheels, and thus its circumferential travel indicates distance run; at the same time another pen, jerked at half second intervals by a clock, records time. Other pens actuated by strings led over pulleys, record the change of level of the ends of the model. Thus the diagrams made furnish an exact measure of the speed, and a continuous record of the resistances and of the change of level of the model throughout the experimental run at steady speed. While starting or stopping, the model is controlled by hand levers to prevent the dynamometric spring being over-strained.

No. 8. A "designer" template.

This consists of one of the pile of adjustable templates shown in photograph No. 1, and already described.

No. 9. A segment of a model.

This specimen segment of a model is partly in a finished condition and partly in the condition in which it is left by the shaping machine, Nos. 3 and 4. It thus shows the series of water-line cuts made by the machine, and a part of the original cast surface remaining between the cuts.

2147aa. Model of the solid of "**Least Resistance,**" by the late Andrew John Robertson, dated 1861.

Michael Scott, London.

2147ab. Model of the Steam Ship **"Sir John Lawrence,"** embodying to a considerable extent the form of least resistance, designed by Michael Scott, in conjunction with the late Andrew John Robertson. The performance of this ship was excellent.
Michael Scott, London.

2147ac. Three diagrams of a new type of **War Ship,** designed by Michael Scott in 1869, and published in 1870.
Michael Scott, London.

In this design the surface exposed to hostile fire is diminished by constructing the vessel with a central fort, armour plated all round, an armoured deck under water, and dividing the space above this armoured deck for a height of six feet into water-tight compartments, which would be filled with fuel or water when going into action. She is intended to carry both turret and broadside guns, and might be armed with a submarine weapon.

2147ad. Three diagrams of new type of **War Ships,** designed by Michael Scott in 1870, and published in 1871.
Michael Scott, London.

In this design there is a central fort, armour plated all round; an armoured deck under water sloping downwards towards the bow, so as to prevent the vessel from being raked in a seaway, and strengthening the ramming beak. The ship is intended to carry sail, her turrets to be placed abreast, and also to carry broadside guns.

Some of the most important features in these designs have been adopted in the most modern war ships.

2147a. Model of Bermudian Sailing Boat "Pearl."
William Moody.

2147b. Model showing the method of framing a screw aperture of a line-of-battle ship, to enable the screw or propeller to be raised or lowered at pleasure. *William Moody.*

2147c. Model of a midship section of a first-rate, showing the method of framing a ship. *William Moody.*

2147d. Model of the State Barge in which William III. landed at Greenwich, 1689. *William Moody.*

2147e. Model of Bow of a first-rate. *William Moody.*

2147f. Bow of a First-rate showing the disposition of the frame timbers and hawse pieces. *William Moody.*

2147g. Stem of a 50 gun Frigate showing the disposition of the stem timbers. *William Moody.*

2147h. Stem of a 50 gun Frigate showing the disposition of the stem timbers. *William Moody.*

2147k. Jury Rudder as fitted to the "Intrepid," Arctic discovery vessel. *William Moody.*

21
1873
tons.
Iron
Argenti
Rigged

217
Shêng
256 to
Iron
Vavass
These

217
1875.
tons.
Armo
Argenti
8 inches
They s
from the

SERIES
Pr
La

2178
Length
horse-p
The fi
taken to
river, wh

217
130 ft.,
horse-p
Paddle
the navig
time. A
and she w
About
the dispo
ments on
by Capt.
search
steam

2178
Length
power.
Built
at the

lf-block Model of S.S. "Viceroy." Built
120 ft., breadth 37 ft. 6 ins., depth, keel to upper
ins., depth, keel to main beams, 32 ft. 3 ins.
. Tons nett register 1,851. *R. and H. Green.*

lf-block Model of Ironclad Ram "Ara-
for the Spanish Government, 1863. Length
eadth 54 ft., depth 32 ft. 5 ins. Tons burthen
ngines, horse-power 800 nominal. 34 guns.
R. and H. Green.

lf-block Model of H.M. Ironclad Batteries
ad "Trusty." Built 1855. Length 172 ft.
45 ft. 1 in., depth 14 ft. 9½ ins. Tons 1,546.
ower 150 nominal. *R. and H. Green.*

ole Model of East Indiaman "Falmouth."
R. and H. Green.

ole Model of Merchant Sailing Ship
n." Built 1837. *R. and H. Green.*

f-block Model of Paddle Tug "Rienzi."
ngth 114 ft. 6 ins., breadth 20 ft., depth 11 ft.
$\frac{15}{14}$. Horse-power 70 nominal.
R. and H. Green.

lf-block Model of Sailing Ship "Agamem-
1855. Length 244 ft., breadth 36 ft. 6 ins.,
. Tons 1,536$\frac{67}{94}$. *R. and H. Green.*

lf-block Model of Sailing Ship "Nile."
ngth 173 ft. 8 ins., breadth 36 ft. 6 ins., depth
38$\frac{29}{94}$. *R. and H. Green.*

lf-block Model of Sailing Ship "Carna-
33. Length 130 ft. 6 ins., breadth 32 ft. 6 ins.,
s. Tons 595. *R. and H. Green.*

lf-block Model of Sailing Ship "Mel-
lt 1874. Length 260 ft., breadth 40 ft., depth
ister 1,965, tons O.M. 2,008. *R. and H. Green.*

lf-block Model of Sailing Ship "Carlisle
gth 220 ft., breadth 38 ft., depth 22 ft. 10 in.
58, tons O.M. 1,514. *R. and H. Green.*

wing, Profile of Captain Dicey's Channel
talia." *Thames Iron Works Co., Millwall.*

2178ch. Model of the Screw Steamer "City of Richmond." Length 440 ft., breadth 43 ft. 6 ins., depth 34 ft. 4,606 tons gross. *David and William Henderson & Co.*

Built and engined by the late firm of Tod & McGregor in 1873, for the Inman Line to trade between Liverpool and New York. Ship rigged.

Engines, direct acting compound inverted, cylinders 76 ins. and 120 ins. diameters, length of stroke 5 ft.; propeller 22 ft. diameter; horse-power 670 nominal; speed at trial trip, 17 knots per hour; 10 boilers, 30 furnaces.

... Steamer "Princess ... t., breadth 28 ft., depth 15 ft. ... tons gross. ... *William Henderson and Co.*

Built by the late firm of Tod & ... or in 1861, for the Glasgow and Liverpool trade, schooner rigged.

Engines, direct acting inverted, ... nded in 1873 by having 2 high pressure cylinders 24 inch diameter ... on top of the 45 inch cylinders—length of stroke 2 ft. 6 ins., horse-pow... nominal, propeller 12 feet diameter, speed 12 knots per hour.

2178cj. Model of the ... Steamer "Lady Nyessa." Dimensions, length 150 ft., ... 14 ft., depth 6 ft. *Dav... William Henderson and Co.*

Built by the late firm of Tod & McGregor in 1861, for the late Dr. Livingstone, for exploration in Central Africa. To facilitate transportation of the vessel from the Zambesi to Lake Nyessa, she was constructed in 12 segments in her length, each segment being in two pieces which were bolted together through angle iron frames. Dr. Livingstone on his return home from Africa, on his first exploration, sailed in her from the Zambesi to Calcutta. The "Lady Nyessa" was fitted with two propellers, one abaft the other on the same shaft.

Engines high pressure, cylinders 14 ft. diameter, length of stroke 12 inches, horse-power 25 nominal.

2178ck. Model of the Screw Steamer "Bengal." Dimensions, length 297 ft., breadth 39 ft., depth 27 ft. 6 ins. 2,235 B.M. tons. *David and William Henderson and Co.*

Built by the late firm of Tod & McGregor in 1852, for the Peninsular and Oriental Steam Navigation Co., lately trading in the China Seas.

Engines beam geared, cylinders 80 inches diameter, stroke 5 feet, horse-power 470 nominal.

2178cl. Model of the Paddle Steamer "Trafalgar." Dimensions, length 190 ft., breadth 28 ft. 6 ins., depth 16 ft. 4 ins. 689 tons gross. *David and William Henderson and Co.*

Built and engined by the late firm of Tod & McGregor in 1847, for Messrs. Wm. Watson & Co., Dublin, for their Liverpool and Dublin trade, schooner rigged.

Engines oscillating, cylinders 69 inches diameter, length of stroke 5 feet 6 inches, horse-power 360 nominal.

2178cm. Model of the Paddle Steamer "Princess Royal." *David and William Henderson and Co.*

Built and engined by the late firm of Tod & McGregor in 1841, for the Glasgow and Liverpool trade; wrecked in 1856, and a new paddle steam vessel built in 1857 to replace her.

Engines, steeple, cylinders 72 inches diameter, length of stroke 6 feet 6 inches, horse-power 400 nominal.

2178cn. Model of the Paddle Steamer "Countess of Galloway." Length 165 ft., breadth 24 ft., depth 14 ft. 3 ins.

David and William Henderson and Co.

Built and engined by the late firm of Tod & McGregor. Two vessels were built from this model and of the same name, one in 1835 and one in 1843, fitted up as passenger and cattle-boats plying between Liverpool and Wigtown; the latter vessel is still on her station, and is considered one of the best cattle-boats afloat. Owned by the Galloway Steam Navigation Company, rigged 3-masted schooner.

Engines vertical, direct-acting, cylinders 54 inches diameter, length of stroke 5 feet, horse-power 220 nominal, paddle wheel 22 feet diameter.

2178co. Model of the Twin Paddle Steamer "Alliance." Dimensions 140 ft. by 9 ft., breadth of each hull, depth 8 ft., distance between hulls, 12 ft., total breadth, 30 ft.

David and William Henderson and Co.

Propelled by one paddle wheel, 18 feet diameter, placed between hulls, 27 ft. 6 ins. abaft centre of vessel. The paddle wheel was afterwards taken out of the centre and the two halves rivetted together; since that alteration she made several successful passages as a blockade runner during the late American war. The "Alliance" was built by the late firm of Tod & McGregor in 1856, for Clyde river traffic.

Cylinders, 34 inches diameter length of stroke, 3 feet horse-power, 70 nominal.

2178cp. Model of the Merchant Vessel "Brotherly Love." Built in the year 1764, and still reigning. The mark on the side is for damage in a collision with a steamer some years ago.

James Young.

2178cq. Model of the Merchant Vessel "Antelope." Built in the year 1757.

James Young.

2178cr. Model of a Shields Pilot's Coble.

James Young.

2178cs. Model of the Mast of the Man-of-war "Nelson," in seven pieces, without the pieces which form the top.

James Young.

Dimensions, Weight, and Expense of the "Nelson's" Main Mast.

		£	s.	d.
No. 1.	Expense of seven trees - - - -	860	16	6
2.	Hoops, bolts, and nails - - - -	61	11	6
3.	Smith work - - - - - - -	16	4	0
4.	Mast makers - - - - - -	55	0	7¾
		993	12	7¾

	ft.	ins.
Length - - -	127	2½
Greatest diameter - -	0	41
Smallest diameter - -	0	30½

	tons	cwt.	qr.	lbs.
Weight - -	26	0	3	24

2178ct. Photograph of the "Comet" and "Iona" Steamers, 1811, 1874. *John Hamilton.*

From a painting by Wm , to illustrate and keep on record the appearance of the firs , and also to make a comparison between the past and presen river steamers.

2178cu. Half Mod Iron Screw Steamer, showing about 23 ft. of , with a Price's patent self-turning hatchway fittec *William Denton.*

The adoption of this new opening in the vessels already fitted with Price's patent has rge saving in the cost of loading, as trimming is entirely dispens pamphlet containing testimonials explains the opinions of the have adopted the invention. With a lithograph showing p el fitted with Price's hatchways, also detailed sketches of manne lf-booms, hatch sides, &c.

2178cv. Half Model of Iron Merchant Vessel "Donnybrook." Length 260 ft., breadth 40 ft., depth 24 ft. Built 1876 by Messrs. Austin and Hunter. Tonnage 1,700 tons, water draught 21 ft. *Austin and Hunter.*

2178cw. Half Model of Carr's Steamer "Decapolis," built of iron. Length 260 ft., breadth 32 ft., depth 23½ ft., tonnage 1,000 tons, draught of water 20. Built 1876 by Messrs. Austin and Hunter. *Austin and Hunter.*

2178cx. Model of Merchant Ship "Cherubim." Length 156 ft., keel 136 ft., breadth 28 ft., depth 18 ft. *Thomas Wrightson.*

2178cy. Model of Passenger Steamer "North Star." Length 316 ft., depth 23 ft., breadth 36 ft., tonnage 2,500 tons. *Thomas Wrightson.*

2178cz. Model of the "Crest of the Wave," a noted China clipper, built by the late William Pile, Sunderland, and owned by John Hay, Esq. and others, Sunderland. Built in 1853 of wood. Length 180 feet, breadth 32 feet, depth 20 feet. Classed 13 years A1. in Lloyd's registry; 776 tons register. *R. H. Hay.*

2178da. Model of the wood clipper vessel "Aurora Borealis," built by the late William Pile, Sunderland, and owned by John Hay, Esq., Sunderland, in 1850. *R. H. Hay.*

2178db. Model of the wood clipper vessel "Herald of Light," built by the late William Pile, Sunderland, in 1850, and owned by Henry Ellis, Esq., London. *R. H. Hay.*

2178dc. Model of the stern of an iron sailing ship fitted with patent rudders, to be used when the main rudder is damaged or carried away; also to be used in conjunction with the main rudder when required. *George Stavers.*

2178dd. Model of the stern of a steamer fitted with patent rudders, to be used when the main rudder is damaged or carried away. *George Stavers.*

They can also be used in conjunction with the main rudder to increase the steering power to prevent collisions. The wheel is fitted with a double set of tiller ropes; the fore one connects the main rudder and the after one the patent rudders.

2178de. Model of the "Dover Castle" (wood). Built for Richard Green, Esq., Blackwall, in 1858. Length 185 ft., breadth 22 ft., depth 34 ft., tonnage 1,002 nett. *John Haswell.*

This vessel was draughted and model made by Master George Haswell, son of the builder, when 15 years old.

2178df. Model of the "Min" and "Sumida," sister ships. Built for the Japanese Government by R. Thompson, junior. Length 268 ft., breadth 32 ft. 1 in., depth 21 ft. 4 ins. *Robert Thompson, junior.*

2178dg. Model of the "Lady Louisa." Built for Wilson and Co., London, by R. Thompson, junior. Length 152 ft., breadth 28 ft. 3 ins., depth 17 ft. 9 ins. *Robert Thompson, junior.*

2178dh. Model of the "Life Brigade." Built for E. Shotton and Co., North Shields, by R. Thompson, junior. Length 249 ft. 5 ins., breadth 32 ft. 4 ins., depth 17 ft. 15 ins. *Robert Thompson, junior.*

2178di. Model of the "Graham" (wood). Buillt for Edmund Graham, Newcastle, by Robert Thompson and Sons, designed by Robert Thompson, junior. Length B.P. 132 ft., breadth 30 ft. 4 ins., depth of hold 20 ft. 10 ins. *Robert Thompson, junior.*

2178dj. Model of the "Opal." Composite corvette, by William Doxford and Sons. Length 220 ft., breadth 40 ft., depth 21 feet. *Wm. Doxford and Sons.*

2178dk. Model of the Screw Steamer "Adalia." Built for E. T. Gourley, Esq., M.P., by William Doxford and Sons. Length 231 ft. 6 ins., breadth 32 ft., depth 24 ft. 8 ins. *Wm. Doxford and Sons.*

2178dl. Model of Composite Gunboat "Cygnet." By William Doxford and Sons. Length 125 ft., breadth 23 ft. 6 ins., depth 12 ft., horse-power 360. *Wm. Doxford and Sons.*

2178dm. Model of Passenger Screw Steamer "Gloria" built for Olano Larrinaga & Co., Liverpool, by William Doxford and Sons. Length 322 ft., breadth 38 ft. 3 ins., depth 30–55.
Wm. Doxford and Sons.

2178dp. Set of Original Block Models from which the following vessels were built in wood:—

"Victory," barque, built in 1847, length 113 ft., breadth 22 ft. 8 ins., depth 13 ft. 6 ins. Classed 7 years A1., tonnage 239 tons.

"St. George," Snow collier, built in 1847, length 78 ft., breadth 23 ft., depth 12 ft. 3 ins. Classed 8 years A1., tonnage 153 tons.

"Providence," schooner, fruit trade, built in 1850, length 69 ft., breadth 17 ft., depth 10 ft. Classed 7 years A1., tonnage 83 tons.

"Bury St. Edmunds," full-rigged ship, built in 1853, length 155 ft., breadth 31 ft., depth 21 ft. Classed 13 years A1., tonnage 701 tons. *Peter Forster.*

2178dq. Model of the Composite Clipper Sailing Ship "Torrens" (Elder line of packets to Adelaide). Built by James Laing, Sunderland, in 1875. Length 222 ft., breadth 38 ft., depth 21 ft. 6 ins. 1,334 tons, gross. *James Laing.*

2178dr. Model of the Peninsular and Oriental Steam Navigation Company's Vessels "Khiva" and "Kashgar." Built by James Laing, Sunderland, in 1874. Length 370 ft., breadth 36 ft. 8 ins., depth 27 ft. 4 ins. 2,600 tons gross.
James Laing.

2178ds. Model of the Hamburg South American Steam Ship Company's S.S. "Buenos Aires." Built by James Laing, Sunderland. Length 340 ft., breadth 36 ft. 4 ins., depth 25 ft. 6 ins. 2,400 tons gross. *James Laing.*

2178dt. Model of Sailing Ship "Vimiera." Built in 1850 by James Laing, Sunderland, for the late Duncan Dunbar. Length 165 ft., breadth 33 ft., depth 23 ft. 1,037 tons.
James Laing.

The side of this model can be opened to show the construction of the ship.

2178du. Model of the Peninsular and Oriental Steam Navigation Company's S.S. "Poonah," as altered and refitted by James Laing, Sunderland. Length 414 ft., breadth 41 ft. 6 ins., depth 27 ft. 4 ins. 3,118 tons gross.
James Laing.

2178dv. Model of Screw Steamer "Lestris." Built by Joseph L. Thompson and Sons, Sunderland. Length 227 ft., breadth 30 ft., depth of hold 17 ft. *Joseph L. Thompson and Sons.*

2178dw. Model of Sailing Ship "Baroda." Built by Marland and Wolfe, Belfast. Length 225 ft., breadth 36 ft., depth 23 ft. 9 in. *P. Phorson.*

2178dx. Model of a Vessel built about 1844 by James Leithead Pallion, Sunderland. *P. Phorson.*

2178dy. Model of the wooden Ship "Chowringhee." Built by the late Wm. Pile, of Sunderland, for the late John Hay, Esq., in 1857. Length 156 ft. 3 ins., breadth 31 ft. 6 ins., depth 21 ft. 6 ins. *Sunderland Corporation.*

2178dz. Plans and Elevations of Steamships "Marquess de Nuney" and "Wear." Built by the late Mr. Wm. Pile, Sunderland. *Mr. Skinner, Sunderland.*

2178ea. Model of Screw Collier "David Burn." Built in 1873 by Messrs. Wm. Doxford and Sons, Sunderland. *Alfred Simey and Co., Sunderland.*

This vessel was sunk off the Tyne by collision on her first trial trip. The visitors (chiefly ladies) were saved by the captain of the vessel which struck her, keeping her going at full speed, and filling the hole made by the collision

2178eb. Two Models of parts of a vessel, with the day and night helm indicating signal hoisted for preventing collisions at sea. *John James Nickoll.*

On moving the helm either to port or starboard, the indicator will move, showing which way the helm is, and consequently which course a vessel is about to steer.

2178ec. Transparency showing the effects of the helm indicating signals for preventing collisions at sea. *John James Nickoll.*

2178ed. A pair of Coloured Lenses for railway and other signals, calculated to show the signals upwards of two miles. *John James Nickoll.*

The green signals can be seen at a much shorter distance than the red; this green lens will show a distance of *three miles.*

2178ee. Model of an Anchor invented by Sir Edward Belcher when a midshipman, 1815. *Admiral Sir Edward Belcher, K.C.B.*

2178ef. Model of a method of mending an Anchor when the shank has been broken, 1830. The method is by means of 3 pieces of pig-iron. *Admiral Sir Edward Belcher, K.C.B.*

2178eg. Model in Silver. Patent "Stockless" anchor, small craft anchor. *Wasteneys Smith, C.E.*

2178eh. Model in Brass. Patent "Stockless" anchor. *Wasteneys Smith, C.E.*

These anchors are said to possess—

1. Great holding power, with less weight, besides being diminished in the weight of the stock.
2. Extraordinary strength, proved at Lloyd's test.
3. It is always canted, no matter how it falls, and requires no stock to keep it canted.
4. Being always canted when on the ground, and by the assistance of the horns or toggles, it takes hold as soon as any strain is put upon the cable.
5. Spare, and wider, and different shaped arms for various grounds may be carried on board.
6. It will not foul or get fouled, and when holding there is nothing above ground, nor is there any stock to cause accidents.
7. It trips with great ease, because there is no stock to lift, and the crown end has so large a surface that good purchase is obtained for weighing.
8. It is easily fished, and can be stowed in-board on deck, thus clear of the bow, and avoiding risk of damage in case of collision of any description.
9. A ship may speedily be brought up by it, and ride with very short cable; the steadying power being at the crown end, it is of no object if the shank is raised off the ground, which stocked anchors will not allow.
10. In shallow water no damage can occur to a ship's bottom, as no part of the anchor projects above ground.
11. It is at least one-third shorter than ordinary anchors, therefore soon clear of the water, and more convenient to manage.
12. It can readily be disconnected, thus convenient to stow and easy to transport in case of need, its heaviest part being less than one-third its total weight.
13. It is made without welding, thus of great soundness.
14. It is worked with only one davit (being hoisted and let go by the fish shackle), therefore considering the saving of first cost and future maintenance of one davit and blocks, &c., it is by far the cheapest anchor to use, besides greatest safety and simplicity in working.
15. It is not dangerous when at "wash," for in the event of a collision, the arms would simply be flattened to the ship's side instead of being driven in.
16. Should the anchor be difficult or dangerous to weigh, from having got fast in rock or wreckage, a runner with messenger attached may be slipped down the cable to the crown end, and by this means the anchor can be drawn out freely, as there are no barbs or palms to retard it.
17. Being of such greater strength and holding power, and requiring less cable than other anchors, shorter and stronger cables may be carried, thus increasing the safety of the ship without additional weight or cost.

2179. Model of **J. Ericsson's Screw Propeller Engines,** applied to the American and Swedish Monitors, patented in America in 1858.

Lent from the Patent Office Museum by the Commissioners of Patents.

2180. Models of Screw Propellers.

Council of King's College, London.

2180a. Model of a Propeller for Ships.
S. F. Pichler, London.

2180b. Model of Bevis's Patent Feathering Screw Propeller. *Laird Brothers.*

Mr. R. R. Bevis, managing engineer to the firm of Messrs. Laird Brothers, of Birkenhead, in 1868 patented an arrangement for altering the pitch or feathering the blades of a screw propeller in a fore and aft direction, which claims to be a great advantage for screw steamers, making them faster and more handy when under sail alone, and when under steam and sail allowing of adjusting the pitch to obtain the best result. A screw propeller of the ordinary kind, whether fixed or revolving, is a heavy drag against speed and handiness for sailing, and "lifting" it is a laborious operation, and requires a large hole or well through the ship's counter to admit of so doing.

The arrangement of this new screw propeller is free from many of the objections which have been made to feathering screws previously tried. The gear for feathering the blades is well protected, the levers and other gear that move the blades being enclosed within the boss of the screw propeller, and attached to a rod passing through the centre of the shaft, which is worked in the screw shaft tunnel. This system is admirably adapted for ships of war or sailing ships with auxiliary power or yachts, where it is as important to have a good result under sail alone as under steam. The operation of altering the pitch, or of feathering the blades to any angle, is done in a few minutes, without in any way putting the engines into a position that they may not be used in an emergency.

2180c. First Helmet made for Diving Purposes, date A.D. 1829. *Siebe and Gorman.*

2180d. Patent Helmet for Diving, fitted with segmental neck ring and safety locking arrangement, inflating valve for bringing diver to the surface. Fitted with speaking apparatus to enable the diver to communicate with his attendant. Used on board H.M. Ships of the Royal Navy. *Siebe and Gorman.*

VIII.—LIGHTHOUSES AND FOG SIGNALS.

2181. Model of a **Lighthouse** built upon the **Bishop Rock,** 7 miles from land, forming part of the outermost reef S.W. of the Scilly Islands. *Trinity House, London.*

The tower is of Cornish granite (Carnsew), and is surmounted by a lantern of gun-metal, containing lenticular apparatus to exhibit a fixed light of the first order, whose focal plane is 110 feet above high-water spring tides. The structure measures from base to vane 147 feet. It was built from designs by the late James Walker, M.I.C.E., under the superintendence of Nicholas Douglass, for the Corporation of Trinity House, London, at a cost of 36,500*l.*, and occupied six years in construction; it was completed in 1853. A sectional drawing shows the method of bracing by vertical and radiating wrought-iron ties, lately adopted for strengthening the structure.

2182. Model of a **Lighthouse** now building upon the **Little Basses Rock,** part of a reef about 7 miles S.S.E. of the coast of Ceylon. *Trinity House, London.*

The tower is of Scotch granite (Dalbeattie), each stone of which was dressed, fitted, and marked in this country, freighted to Galle, and thence carried to the rock and fixed in its place. The light is intended to be of the first order, dioptric, on the group-flashing principle, showing two flashes in quick succession every minute, at an elevation of 110 feet above high-water spring tides.

The rock is awash at low water, and is exposed to heavy seas during both the N.E. and S.W. monsoons, and while the latter prevails is inaccessible for work. The drawings show the methods of landing stone in a seaway by steam-power.

This lighthouse, as well as its fellow on the Great Basses just completed, is building from designs by James N. Douglass, M.I.C.E., under the superintendence of William Douglass, M.I C.E., for the Corporation of Trinity House, London, acting on behalf of the Home and Colonial authorities.

Its cost is estimated at 73,000*l.*, and completion is anticipated within five years from date of commencement.

2182a. Lantern and Apparatus intended for the Little Basses Lighthouse, Ceylon. *Trinity House, London.*

The lantern is of the cylindrical type adopted by the Trinity House, its form gives maximum strength, and secures greater optical accuracy than the earlier methods of flat glazing. The gun-metal framing is inclined about 30° from the perpendicular, and is helically curved throughout, thus reducing to a minimum the obstruction offered to the light sent forth from the lenses.

The optical apparatus, constructed upon the group-flashing principle, designed by J. Hopkinson, B.A., D.Sc., at the glass works of Messrs. Chance Brothers, is the first dioptric instrument of its kind adopted by the British lighthouse authorities. It is 12-sided, and makes a completed revolution in six minutes, so that the panels being arranged in pairs, a double-flash meets the eye of the observer once a minute.

The lantern and apparatus prepared for this structure are exhibited in working order in the grounds outside the Museum.

2183. Drawing of a **Light Vessel** with deck plans showing internal arrangements and disposition of Syren **Fog Signal** machinery. *Trinity House, London.*

The hull is designed after that of the vessel now at South Sand Head (Goodwin), built last year, of about 212 tons, and fitted with a syren fog-signal, giving one blast every two minutes, by means of compressed air, at a pressure of 30 lbs. to the square inch, the apparatus being driven by a caloric engine, which also works the windlass.

The illuminating apparatus represents that in use at the Royal Sovereign Shoal, off the coast of Sussex; it is catoptric, and is upon the "group-flashing" principle, giving three flashes in quick succession every minute. The crew space is for seven men, including the officer in charge. The hollow iron mast affords access to the lantern, and allows of the lamps being trimmed in all weathers without danger of extinction.

2184. Two **Syrens,** each a portion of the present **First Class Fog Signal,** and a diagram showing the method by which they are put in action. *Trinity House, London.*

The disc syren, with the trumpet by which its sound is directed, is shown in the diagram. It is composed of a fixed disc, forming one end of the chamber into which steam or compressed air is forced, and a movable disc rotating rapidly by separate mechanism outside it. Both are perforated by 12 radial slits exactly corresponding each to each, and the rotation of the moving disc, close to and upon a common axis with its fixed associate, permits the compressed air or steam to escape when the slits coincide, and shuts it off when they do not. The vibrations thus produced being repeated in the instrument described, at the rate of more than 400 per second, emit a sound of very great intensity, which is directed by the trumpet towards any desired point.

The cylindrical syren is a later form of the instrument, in which the chamber for compressed air surrounds a fixed cylinder having 24 slits, within which another cylinder coincidently perforated rotates, and the vibrations pass through the open end of the inner cylinder to the trumpet.

Syrens sounded by steam have for some time been used for fog-signalling on the coasts of America, and have lately been adopted, with the substitution of compressed air for steam, in Great Britain as a result of experiments made by the Trinity House with the assistance of Professor Tyndall during the winter of 1873.

2185. Fog Signal Apparatus. Designed by Dr. G. Amadi, of Trieste.

The Imperial and Royal Maritime Government at Trieste.

By this apparatus deep tones, like those of an organ, are produced by metallic tongues, driven by steam, and sent through a trumpet in a given direction. These, from experiments, have extended as far as 16 nautical, or nearly four German miles.

In working this apparatus, of which already three are in use, at Trieste, Salvore, and Grado, the sounds are made self-producing at certain intervals by means of a steam-engine.

2185a. Holmes' Shipwreck Distress Signal Flare and Life Buoy Rescue Lights.

These have the remarkable property of bursting into flame when placed in contact with water, and when once ignited are absolutely inextinguishable by either wind or water. They emit a most powerful white light, as brilliant as the magnesium light, and continue to burn over 30 minutes. The shipwreck distress signal flare is visible on a dark night with a clear atmosphere at a sufficient elevation for over ten nautical miles, and burns with greater brilliancy the more seas sweep over it.

The light is a chemical light, and produced by the action of the water upon phosphuret of calcium, giving off phosphuret of hydrogen, which, combining with the oxygen in the atmosphere, spontaneously ignites. These distress signals are free from danger, are not affected by heat, friction, or percussion, and contain no explosive compound whatever.

2185b. Holmes' Mechanical Compound Reed Fog Horn.

These mechanical fog alarms are constructed upon the most approved acoustical principles, and emit a most powerful sound. The "aurora" fog horn can be heard over three nautical miles, and the note produced is the 8 foot C of the musical scale. The tone is produced by the vibrations of two metal tongues, placed together in absolute contact, and closing the same reed,

...ns (the split tongue) a powerful vibration is set up with a ...ssure of air. The air bellows consist of two metal cylinders, ...nside the other; and the compressed air upon the return of ... driven through the reed into an inner trumpet-shaped tube cont... within and a part of the external cylinder.

2186. Parabolic Reflector of 21-inch aperture.
Trinity House, London.

Composed of copper coated with pure silver in the proportion of 3 ozs. (troy) pure silver to 1 lb. (avoirdupois) copper. Its focal distance is 3 inches.

Improvements in the ... ...ht vessels' lanterns have permitted the introduction of ... ...tor into that service, in which a 12-inch aperture had ... ...t of size.

2187. ... A mechanical arrangement used for c... of the clockwork machinery, by means ... to revolve on board a light ship.
Trinity House, London.

Before this contrivan... ...y Mr. Slight of the Trinity Workshops, there was always ... ...egularity in the periods of duration of the light and the interv... ...ut the centrifugal governor ensures the working of the revolving ... ...th very great accuracy.

2188. An **Improved Six-Concentric-wick Lamp,** for burning vegetable or mineral oil.
Trinity House, London.

The burner hitherto in use for dioptric apparatus of the first order has carried four concentric wicks, and in burning has been maintained at full power in all weathers. In the improved six-wick burner, designed by J. N. Douglass, M.I.C.E., only the three outer wicks are to be used in ordinary weather, and in thick weather the three inner wicks (at other times cut off by a concentric reflector) are also brought into action. The full light-producing power of the six-wick lamp is equal to 722 standard sperm candles, attained by a consumption of 1 gallon of oil in 1 hour 50 minutes; its half-power equals 342 candles, with 1 gallon consumed in 2 hours 45 minutes. By a simple arrangement regulating the level of oil in the burner, and the position of the air-deflectors, the lamp can be made to burn any description of oil at pleasure.

2189. A **Panel** of **Cata-Dioptric Apparatus, One** of a set of **Polyzonal Lenses** manufactured in 1836 by Messrs. Cookson and Sons, of Newcastle, for the Trinity House of London, and by them fixed in the Start Point Lighthouse, Devonshire.
Trinity House, London.

The first lenticular apparatus used in an English lighthouse, with a central lamp upon Fresnel's principle.

2190. Plano-Convex Lens, used at Portland Lighthouse in the year 1789.
Trinity House, London.

It is 22 inches in diameter, and was placed in front of an argand burner and reflector. It is believed to be one of the lenses first used in combination with an oil lamp and reflector for lighthouse illumination.

2191. Facet Reflector. Specimen of a reflector and lamp used first at Liverpool about the year 1763, and afterwards at Lowestoft and other lighthouses. *Trinity House, London.*

It is made of wood with facets of silvered glass, is nearly paraboloidal in form, and is the earliest kind of reflector known to have been used in aid of an oil lamp in lighthouse service.

2192. Lamp and **Reflector,** as used in English floating lights about the year 1809. The curve of the reflector is spherical.

Trinity House, London.

2193. Parabolic Reflector of **Plated Copper,** used in some of the **Northern Lighthouses.** When the apparatus is to be cleaned, the lamp is lowered out of the reflector on a sliding carriage, as arranged by the late Mr. Robert Stevenson in 1814. The object of the sliding carriage is to insure the return of the burner to the proper focus.

W. and T. Stevenson, Northern Lighthouse Office.

2194. Parabolic Reflector, formed by small facets of mirror-glass, imbedded in plaster of Paris, used in the earliest of the northern lighthouses till superseded by more perfect apparatus in the beginning of the present century.

W. and T. Stevenson, Northern Lighthouse Office.

2195. Model of a **First-class fixed Dioptric Light;** scale, one-fifth of full size.

W. and T. Stevenson, Northern Lighthouse Office.

This apparatus consists of a central lenticular band, and an upper and lower set of reflecting prisms. The cylindrical belt with diagonal joints and the upper and lower reflecting prisms were substituted by Mr. Alan Stevenson, in 1836, for the segmental belt, and upper and lower silvered mirrors of Fresnel's first-class apparatus.

2196. Model of a **First-class Fresnel Revolving Apparatus,** as made for Skerryvore Lighthouse in 1843 ; scale, one-fifth of full size.

W. and T. Stevenson, Northern Lighthouse Office.

The light is received and collected into eight horizontal beams by the principal lenses—the light which would escape above is collected into eight inclined beams by small lenses, and reflected to the horizon by inclined mirrors. The lower part of the light is sent equally to all parts of the horizon by prismatic rings of glass, which act as mirrors. The rings at Skerryvore are the first that were made of the largest or first order size, and were undertaken by M. Soleil, on the proposal of Mr. Alan Stevenson.

2197. Model of a **First-class Holophotal Revolving Apparatus;** scale, one-fifth of full size.

W. and T. Stevenson, Northern Lighthouse Office.

part of this apparatus consists of eight of Fresnel's lenses. ... passes above and below these lenses is collected into eight ... beams by reflecting prisms. These reflecting prisms were substituted for the inclined lenses and mirrors of Fresnel's first-class revolving apparatus by Mr. Thomas Stevenson, and were first used by him at Singapore, in 1849, on a small scale, and adopted on a large scale at North Ronaldshay, in Orkney, in 1851.

2198. Dioptric Holophote, designed by Mr. T. Stevenson for lighthouse illumination.

Northern Lighthouse Office.

This apparatus c... the lamp into one beam of parallel rays solely by mea... tus constituting the front half of the instrument b... it into a beam of parallel rays, while the prisms ... half are so formed as to prevent any ligh... every ray to return back to the flame, a... the front half, so as to increase the intensity of the emergent beam ... red ball is fixed on a wire, so as to be in focus, to illustrate the action ... instrument. To an observer, the front half of the apparatus will ... of red light, but in the back half no red is to be seen, though the ... carries the ball, not being in focus, is distinctly visible.

2199. Fixed Azimuthal ...densing Light. Designed for the leading lights of the River Tay, by Messrs. Stevenson, civil engineers, Edinburgh.

W. and T. Stevenson, Northern Lighthouse Office.

It is remarkable from its employing every kind of dioptric apparatus. The whole of the light coming from the flame is spread equally over a horizontal arc of 45° by means of the following instruments; viz., Fresnel's fixed-light apparatus and annular lens, and Mr. T. Stevenson's condensing prisms, holophote, right-angled conoidal prisms, and dioptric spherical mirror, with Mr. J. T. Chance's setting.

2200. Model of an **Apparent Light.**

W. and T. Stevenson, Northern Lighthouse Office.

A beam of light, projected on the apparatus in the lantern on the beacon from a lighthouse on the shore, is reflected or refracted in such a manner as to indicate the position of the beacon at night. It was first used at Stornoway, in Scotland, in 1852.

2201. Model of the **Lamlash Apparatus,** showing the new twin prisms lately described by Mr. Thomas Stevenson in "Nature," which are now for the first time being constructed, and the new back prisms first introduced at Lochindaal Lighthouse, in Islay. *W. and T. Stevenson, Northern Lighthouse Office.*

2202. Lighthouse Apparatus.

1. Lens with échelons. 1st essay.	Fresnel,	inventor,	1819.
2. Polygonal lens, of the first order.	Do.	do.	1820.
3. Annular lens, of the first order.	Do.	do.	1821.
4. Apparatus for fixed lights.	Do.	do.	1824.
5. Apparatus with catadioptric rings.	Do.	do.	1825.

6. Lens with catadioptric rings, constructed in . 1825.
7. Model of apparatus with catadioptric rings. Fresnel, 1825.
8. Burner with 4 wicks, constructed after experiments made by Arago and Fresnel in . . . 1820.
9. Burner with 2 wicks, with external covering, by Henry Lepaute . . . . . 1845.
10. Burner with 4 wicks, storied, for mineral oils.
11. Large annular lens of Barbier and Tenestre . 1876.
12. Lenticular pannel for flashing lights of Henry Lepaute 1876.
13. Apparatus for revolving electric lights, of Sanker, Lemonnier & Co. . . . . . 1876.

Lighthouse Service of France, Paris.

2202a. Echeloned Lenses.

Lighthouse Service of France, Paris.

No. 1. First essay of echeloned lens, polygonal form. Invented by .. Fresnel, and constructed under his direction in 1819.

No. 2. First echeloned lens, polygonal form, for flashing lights of the first ass. Invented by A. Fresnel, and constructed in 1820.

No. 3. First echeloned lens, annular form, for flashing lights of the first ass. Invented by A. Fresnel, and proceeding from the lenticular apparatus ked on the tower of Cordouan in 1821.

When Fresnel conceived the idea of substituting in lighthouses large glass nses for metallic reflectors, he thought of composing these lenses of several eces, and of calculating the curves of these different pieces so as to rectify eir spherical divergence. He demonstrated his plan before the Lighthouse ommittee in August 1819, three months only after his appointment on the ommittee, and on the 19th of October following he was granted the sum of 0 fr. for constructing a trial lens. He consulted the optician Soleil, who conded him with much good will, but who could only put at his disposal e limited appliances then in use. Glass was at this time worked still by and, and shaped only into plane or spherical forms. Fresnel admitted that e lens should be flat on one side; that the different gradients, instead of rming circular rings, should be defined by polygons and divided into a certain mber of pieces, each of which should receive on its echeloned side a sphe- cal surface properly calculated. Another difficulty arose from the glass ctories being unable to supply in sufficient size pieces of crown glass free om bubbles and striæ; but Fresnel discovered the way of re-smelting glass ithout altering its transparency.

He first constructed a trial lens of 35 centimetres diameter (the one exhi- ited under No. 1). It was given by Soleil to the Academy of Sciences, and posited at the "Conservatoire des Arts et Métiers." It is composed of 21 ieces, glued together, and fixed upon a pane serving as a support.

Emboldened by this first success, Fresnel proposed to the Lighthouse Com- ittee, at their sitting of 31st December 1820, to order the construction of a nticular revolving light apparatus for the Cordouan lighthouse. The prin- ipal part of this apparatus was to include eight square lenses of 76 centi- etres, forming together an octagonal prism inscribed within a cylinder of " diameter. This proposal was adopted, and Mr. Soleil undertook the onstruction of these eight polygonal echeloned lenses. (One of them is xhibited under No. 2.) It is to be seen that it was composed of 100 pieces f glass, glued together, and that the flat pane, which in the trial lens serves s a support, has been done away with. One of these new lenses was first

finished at the beginning of 1827, but they could not be tried until after the inventor's death.

This study shows how Fresnel came to invent not only the section of catadioptric rings, and the use of these rings in fixed light apparatus, but also their applying to annular lenses for flashing lights or for fixed lights. By uniting the pieces of dioptric elements and of catadioptric rings manufactured in Fresnel's time for the apparatus of the St. Martin's Canal, the annular lens exhibited under No. 6 was formed, and it may be considered as the type of all the annular lenses used in the lighthouses of different order

The model in wood, No. 7, represents an apparatus similar to the preceding, but having a diameter of 0·25^{m} instead of 0·20^{m}. It is a study of Fresnel's which he did not carry out.

Lamp Burners.

No. 8. One of the first burners, with four concentric wicks, constructed after experiments made by Arago and Fresnel in 1819–20.

No. 9. Burner, with two wicks and outer wrapper for directing the draught, constructed by Henry Lepaute in 1845.

No. 10. Burner, with five wicks, of graduated shape, for mineral oil, with the last improvements adopted in the lighthouses of France, 1876

When Fresnel undertook the improvement of lighthouses, he had to solve not only the problem of construction of the lenses, but also that of lamps with several wicks. The chemist Guyton-Morvau had already studied the question. In a paper read by him at the Institute in 1797, he stated that he had constructed, 10 years before, a lamp on the argand principle, with three concentric circular wicks, each having an inner and an outer draught. He acquired great intenseness, but the solderings of the burner were destroyed by the heat. About 1800, the watchmaker Carcel invented the lamp that bears his name, and in which the oil at the bottom is forced up by a pump towards the burner above which it overflows. This invention was to lead towards solving the problem of lamps with many wicks. Consequently, when Arago and Fresnel began, in 1819, their experiments with lamps, they forced up the burner oil in superabundance so as to refresh it, and thus avoid the inconvenience met with by Guyton-Morvau. The first trial took place in September 1819 with two-wicked and three-wicked burners, constructed after Fresnel's designs. After several hesitations, respecting chiefly the width to be adopted for the draught between the wicks, they succeeded in constructing a four-wicked burner that gave good results. It was tried 12th May 1820, in presence of the Lighthouse Committee. The burner exhibited under No. 8 is one of those that were constructed according to this first type.

The two-wick burner, No. 9, was constructed by Henry Lepaute in 1845, for the lighthouse of Schevening in Holland. It has an outer cylinder for dividing the draught generated between the glass and the burner, and throwing back a part of it upon the light. It is the first application of this cylinder which exists in all modern burners.

The five-wick burner, No. 10, is a model of those now constructed for using mineral oil in the French lighthouses. It contains an appendage through which the oil must pass before reaching the upper part of the burner. This said piece, of which the arrangements were invented by M. Dénéchaux, acting engineer in ordinary at the lighthouse depôt, is intended to secure a continuous level, and comprises three tubes, juxtaposed, and open on the upper part at the proper height; the central tube springs from the small reservoir which forms the basis of the burner, and in which the oil is forced by the machinery of the lamp; this oil, having no other exit, rises in the tube, and, arriving at the top, flows into the second tube, which

carries it into the annular spaces containing the wicks; these it fills while keeping the same level as in the lateral appendage. As the quantity of oil forced up by the lamp is greater than the consumption, the excess comes down into the large reservoir of the lamp by flowing into the third tube over a fall rather higher than that cleared by the oil in reaching the burner. A horizontal disk of 30 millimetres diameter rises, at the height of 21 millimetres, above the central draught tube, and an outer cylinder divides in two the draught created between the burner and the glass. It is upon this outer cylinder that the glass-holder stands. In this burner the empty spaces between the wicks, intended for air passages, are 5½ millimetres wide, while the spaces that contain the wicks are only 4½ mill. In the burners constructed up to the present time, both widths are of 5 mill.; this new arrangement seems to give better results. The burner has, besides, on its upper part, a graduated shape, so that each wick is placed about 2 millimetres below the one which precedes it towards the centre. This arrangement, as yet adopted only for the Pilier lighthouse, exhibited under No. 12, has been found necessary since the burners, in each order of lighthouses, have had one burner added to them, and therefore are wider. Its object is to lower the edge of the burner, in reference to the centre of the light, so as to reduce as much as possible the portion of light obscured by this edge in the lower part of the lenses. (*See description of apparatus*, No. 12.)

Modern Apparatus.

No. 11. Great annular lens, of the first order, $1{\cdot}10^m$ in diameter, Messrs. Barbier and Fenestre, constructors, 1867. This lens was constructed by Messrs. Barbier and Fenestre as a specimen of high class workmanship. Each ring is one single piece; the joints which divide the rings are inclined according to the direction of the ray refracted. The lens is mounted on a pedestal, and revolves around any horizontal axis.

No. 12. Lenticular panel, dioptric and catadioptric, for flashing lights of the second class, planned by the head engineer, Allard, and constructed by Mr. Henry Lepaute, 1876.

This panel forms part of an apparatus intended for the Pilier lighthouse, situated at the mouth of the Loire, and of which the tower has just been rebuilt. The character given to it in 1829 has been preserved; it is a fixed light varied by flashes every four minutes To produce this character a fixed light apparatus has been adopted, of which two sectors of ⅛th horizon, opposed to one another, are replaced by perfect annular lenses: it revolves at the rate of one turn in eight minutes. In order that the two kinds of lenses may be adjusted upon the edges, and have a common pinion-jack, the focal distance, which is $0{\cdot}700^m$ for the fixed lenses, has been reduced to $0{\cdot}647^m$ for the annular lenses. The focal lamp has five concentric wicks, instead of four, as usual in lamps of the second class, because the light, being coloured red in certain directions, it was thought necessary to increase its intenseness.

This panel shows several novel arrangements, some of which are now applied for the first time.

1st. In the central or dioptric parts of the section, the joints that divide the elements, and therefore the lower sides of these elements, instead of being horizontal, are inclined according to the direction of the ray refracted. This system has several advantages: it does away with a triangular part of glass which is useless, and thus lessens the weight of the apparatus; it reduces in a large proportion the loss of light caused by horizontal joints; it makes less harsh, and consequently less fragile, the outer angles of the elements, and, besides, it diminishes their projection, thus enabling the dioptric lens to acquire a greater height.

[illegible] ntral lens (or dioptric) comprehends a vertical angle of 76 [illegible], in the old sections, this angle was of about 60 degrees only; [illegible] is thus increased from 0·85m to 1·10m. This advantage is thus [illegible], that the luminous rays meet the last dioptric element at the same angle as the first catadioptric ring, and suffer no more loss of reflection upon the one than upon the other.

3rd. The section commonly used in apparatus of the second class had been calculated for a three-wick lamp burner of 0·074m diameter. With a five-wick burner of 1·110m diameter, the inferior elements of the dioptric lens and the lower catadioptric rings, constructed after this old section, emit rays that are no longer in the proper di [illegible] he portion of light which the base of the burner leaves visib [illegible] ibly nearer to the lens than in the case of a three-wick bu [illegible] lefect, a graduated shape was given to the burner, by pl [illegible] below the one preceding it on the side of the centre. [illegible] es neither the regularity nor the intenseness of the l [illegible] st light, visible from each of the lower lenticular el [illegible] hat increased. Moreover, these lower elements have been calcul [illegible] ermining for each of them a particular focus taken on the brigh [illegible] f the apparent part of the light, instead of on the axis itself of tl [illegible] Similar arrangements might be advantageously adopted in many [illegible]

4th. The central lens and [illegible] s are included in the same frame, the upper rings are set in a [illegible] parated from the first by a metal cross-beam. In the annular [illegible] cross-beam takes the shape of the arc of a circle having, like the rings, its centre on the optical axis; the result is that the rings can remain intact, instead of having to be cut, as was the case until now

5th. The lamp, placed at the focus of the lens exhibited, shows special arrangements, due to M. Dénéchaux.

Thus, the skin pockets or valvulæ, and the leathern valves, which are sometimes the cause of disorder, are replaced by ordinary pistons and metal valves. This system has produced good results in experiments made at the depôt, but it has not yet received practical sanction.

The lamp with five wicks for burning mineral oil has an intenseness of 36 carcel burners, the fixed light apparatus produces an intenseness of 640 burners, and the annular lenses produce an effulgence of more than 5,000 burners.

No. 13. Apparatus for electric revolving light, constructed by Messrs. Sautter, Limonnier, & Co., 1876.

This instrument is intended to produce, by electric light, a light revolving at intervals of 30 seconds. It includes a fixed light apparatus 0·50m diameter, lighting the three-fourths of the horizon, around which revolves, in eight minutes, a tambour of 0·62m diameter, and composed of 16 vertical, lenticular elements.

In the section of the fixed light apparatus the central dioptric part fills vertically an angle of 76 degrees, which is greater than in the old sections. This arrangement is adopted in order that the luminous ray may meet the last dioptric element at the same angle as the first catadioptric ring, and should suffer no more loss by reflection upon the one than upon the other. The apparatus having to be fixed on an elevated point, the section of the several parts, except that of the two lowest catadioptric rings, has been calculated so as to throw the focal line of the emergent rays, 30 minutes below the horizontal line; in the calculation of the two lowest rings, this angle is increased by three degrees for the last but one, and by five degrees for the last, so that the lighthouse may remain visible at a short distance, that is, by a navigator placed below the divergent cone emitted by the rest of the apparatus.

The sixteen vertical lenses are contiguous, and are each composed of a single element, about 0·12 wide, the curve of which has been calculated so as to give with the electric light an horizontal divergence of three degrees seven minutes. The duration of a flash is, accordingly, of about five seconds, and the interval between the end of a flash and the beginning of the following one is 25 seconds.

The maximum intenseness of the flash rises to about 60,000 burners, assuming at the focus an electric light of 200-burner power.

The light is produced in this apparatus, as in the lighthouses, with electric light, established on the coasts of France, by means of a Serrin regulator and an electrical machine of the Compagnie l'Alliance.

Experiments have been made with the Serrin regulator at the lighthouse depôt since the year 1860. A model on a large scale has been constructed especially for the lighthouse service, and has always given good results. The regulator exhibited is a counterpart of this model.

The electro-magnetic machine has been, as is well known, designed by MM. Nollet and Joseph Van Walderen, in accordance with the same principle as the scientific apparatus of Pixii and Clarke. It produces alternate currents, and, as it was in the first instance destined for the decomposition of water or for electro metallurgy, it was provided with a commutator for bringing the currents into one constant direction. When the question was raised of applying it to the production of light, M. Van Malderen, who had then become the mechanical engineer to the Compagnie l'Alliance, conceived the happy idea of suppressing the commutator, which is difficult to maintain, and has the effect of more or less weakening the current. The luminous intensity was found to be appreciably augmented, and the fact was soon acknowledged that alternate currents are, *cæteris paribus*, more favourable regulators than those in a constant direction. The machines of the Compagnie l'Alliance had originally six discs; these were reduced to four when the improvements introduced into the coils and the magnets permitted of a greater intensity being obtained with these smaller machines than with the former. In the case of lighthouses, where there cannot be too great intensity, the number of six discs has been preserved.

The central depôt in Paris has retained, since 1860, the first specimen constructed by M. Van Malderen of this machine, with the currents not brought into one constant direction. It has six discs, and carries 56 magnets; it is 1·63 metre high, and 1·43 metre in diameter; it gives less light than the present machines, but it works very well still, and serves for the experiments that are made at the dépôt.

This first machine of the Compagnie l'Alliance may be regarded as the starting point of all the attempts which have since been made of economically transforming power into electricity, and consequently into light. On that account it is no more than right, although the machine is not included in the Exhibition, to make mention of it in the catalogue.

2203. The Original Model of the Eddystone Lighthouse.

The Eddystone Rocks, so named from the great variety of sets of tides and currents which surround them, are situated about 14 miles S.S.W. of the port of Plymouth, the sea being fully 30 fathoms in depth. A lighthouse was constructed on these rocks by Winstanley in 1696, and destroyed by a storm in 1703. A second was built by Rudyerd in 1709, and was totally consumed by fire in 1755. The present lighthouse was commenced in 1756,

...ed in 1759, by Smeaton, F.R.S., civil engineer. This ... model, made by Smeaton, was sent by royal command for the inspection of His Majesty George III. and the Royal Family, and has since then remained in the possession of Mr. Smeaton's family.

Mrs. Croft Brooke.

2203a. Model of the Lighthouse on La Corbière Rock, Jersey. *Sir John Coode.*

The first lig ... ouse ... crete; tower erected in 1874. Sir John Coode, ... neer. ... Joseph Thomas. Scale, $\frac{1}{16}$ of natural size.

2203b. Parabolic ... rendered holophotal, according to Mr. Thomas Steven ... gn, by being fitted with a lens and reflecting prisms, and ... of a spherical mirror, so as to parallelise all the light of th ... Introduced in 1849.

The Com ... ners of Northern Lighthouses.

When the apparatus is to ... the lamp is lowered out of the reflector on a sliding carriage, ... by the late Mr. Robert Stevenson, in 1814. The object of the ... nge is to insure the return of the burner to the proper focus.

2204. Model of First-class Fixed Dioptric Light. This apparatus consists of a central lenticular band, and an upper and lower set of reflecting prisms. The cylindrical belt, with diagonal joints, and the upper and lower reflecting prisms, were substituted by Mr. Alan Stevenson, in 1836, for the segmental belt and upper and lower silvered mirrors of Fresnel's first-class apparatus.

(One-fifth of full size.)

The Commissioners of Northern Lighthouses.

2205. Model of Fourth Order Dioptric Condensing Apparatus for Lamlash Lighthouse, showing the twin prisms, 1875. (One-half of full size.)

The Commissioners of Northern Lighthouses.

2206. Model of Mr. Thomas Stevenson's Marine Dynamometer, for ascertaining the force of waves during storms. The greatest force recorded in the German Ocean was 3½ tons per square foot. *Messrs. D. and T. Stevenson.*

2207. Drawing of Storm Curve, showing the genesis of waves illustrative of Mr. Thomas Stevenson's formula $h=1\cdot5\sqrt{D}$, where h=height of wave in feet, and D=length of fetch in miles.

Messrs. D. and T. Stevenson.

2208. Drawing illustrative of formula for the reductive power of harbours. *Messrs. D. and T. Stevenson.*

2209. Historical Series of published engravings, showing the improvements in lighthouse illumination between 1787 and 1876, by the Engineers of the Northern Lighthouse Board.

Messrs. D. and T. Stevenson.

2210. Example of **French Lighthouses.**

Lighthouse Service of France.

2210a. Polygonal and Annular Lenses. Apparatus for fixed light and for annular reflection; Arago and Fresnel's four-wick burner, two with burner of Henry Lepaute, &c.

Department of Lighthouses, France.

VIII.—MISCELLANEOUS.

2210b. Model of Tumbler Lock and Key.

Council of King's College, London.

2210c. Model of Ancient Egyptian Lock and Key.

Council of King's College, London.

2210d. Model of Mangle Motion.

Council of King's College, London.

2211. Steam Engine. Tangye's (Willan's Patent) three-inch three cylinder steam engine with vertical boiler, feed pump for same, and all fittings complete, on one base plate.

Tangye Brothers and Holman.

This engine is of the simplest construction possible; it is self-contained, has neither eccentrics, separate slide valves, nor piston rod guides, and can be driven at a very high rate of speed without the slightest noise.

2212. Steam Engine. 6-horse power expansion portable steam engine, fitted with Head and Schmidt's patent straw burning apparatus and patent automatic governor expansion gear.

Ransomes, Sims, and Head.

By means of this patent invention all kinds of vegetable substances can now be used as fuel in a portable steam engine, such as straw, reeds, dry grass, cotton and maize stalks, brushwood, &c., and by removing the patent apparatus the engine can also be fired with wood or coal in the ordinary manner.

This engine is also fitted with a separate expansion slide valve, and Brown's patent automatic governor expansion gear, which consists of a link motion attached direct to the expansion valve, and under the control of the governor, by means of which the amount of steam admitted into the cylinder is varied instantaneously in exact proportion to the work to be performed by the engine; an arrangement of the utmost importance in all cases where the load on the engine is suddenly increased or diminished, or where exact regularity of motion in the machine which is being driven is essential to success. The engine has also a simple and efficient arrangement for heating the feed water by means of the exhaust steam, and is provided with two safety valves, steam pressure guage, and all the most modern and complete fittings and accessories.

2212a. Two views of Ramsbottom's Pick-up Troughs at Whitmore.

F. W. Webb, Locomotive Department, London and North-westerm Railway, Crewe.

These troughs are laid down to supply the tenders of the locomotives with water whilst running; a dip pipe on the tender is lowered into the water, which thus runs into the tank, by this means saving time during the journey.

2212b. Dignity and Impudence (after Landseer).

F. W. Webb.

This photograph represent[illegible] and smallest locomotives employed by the London and Nort[illegible] ailway Company. The following dimensions of them may be in[illegible]

	Dignity.	Impudence.
Size of cylinders - -	$17\frac{1}{2}$ in. × 24 in.	$4\frac{1}{2}$ in. × 6 in.
Diameter of driving wheels	8 ft. 6 in.	$15\frac{1}{4}$ inches.
Gauge - - - -	4 ft. $8\frac{1}{2}$ in.	18 inches.
Weight in working order -	$28\frac{1}{2}$ tons	$2\frac{1}{2}$ tons.

2212c. Train used at the **Break Trials,** near Newark, June 9th to 15th, 1875 (2 photos.). *F. W. Webb.*

The train represented was one of the ordinary express passenger trains, fitted with continuous break, sent by the London and North-western Railway Company, to take part in the break trials at Newark in June 1875, before the Royal Commissioners.

2212d. Section of Tabular Results showing the Wear of Steel Rails. *F. W. Webb.*

2212e. Lovell's Patent Apparatus for recording the bad joints on railways and tramways. *Garnham & Co., London.*

This invention is for the purpose of showing the faulty joints in the permanent way, thus providing a means, hitherto unprovided for, for showing in the case of broken springs, or the oscillation of a train, on which side the fault rests, whether in weak springs or bad joints, and consists of a clockwork movement, arranged to draw an endless paper over suitable drums, in combination with a pencil. The indicator is attached between the spring and footplate of an engine or other vehicle, the pencil making a longitudinal line when no oscillation, and a vertical line when oscillation, takes place. The length of such vertical line is various, according to the amount of such oscillation.

2212h. Six Wheels coupled Mineral Engine. Size of cylinders, 17″ dia., 24″ stroke. Diameter of wheels, 4 ft. 3 in. Total weight in working order, 29 tons 11 cwt. *F. W. Webb.*

The barrel of the boiler and fire-box casing are of steel, and the axles and many of the working parts are also of steel.

2212i. Four Wheels coupled heavy Express Passenger Engines. Size of cylinders, 17″ diameter, 24″ stroke. Diameter of coupled wheels, 6 ft. 6 in. Total weight in working order, 32 tons, 15 cwt. *F. W. Webb.*

The frames, barrel of boiler, and fire-box casing, are of steel, and the axles and many of the working parts are also of steel.

2212j. Four Wheels coupled Passenger Engine, for heavy gradients. Size of cylinders, 17″ × 24″ stroke. Diameter of coupled wheels, 5 ft. 6 in. Weight in working order, 31 tons, 8 cwt. *F. W. Webb.*

The barrel of the boiler and fire-box casing are of steel, and the axles and many of the working parts are also of steel.

2212k. Fog Signal, universally used on railways.
E. A. Cowper, Westminster.

This fog signal consists of a small flat tin box, having a little gunpowder inside, and some matches, which ignite on the box, being crushed by the wheel of a passing train, so that a person on a railway can communicate with the driver of a passing train even on the darkest night or during a dense fog.

2213. Apparatus for showing the **Motion** of **Fluids through long Tubes.** *T. Hawksley.*

2214. Model of London and its Environs. Scale 12 inches to a mile. *John Fowler, Westminster.*

Made for the purpose of showing before Committees of the Houses of Parliament the railways existing or in course of construction during the year 1864; also the proposed system of the inner circle railway, comprising the Metropolitan Railway, the Metropolitan and St. John's Wood Railway, and the Metropolitan District Railway.

2215. Improved Method of Reversing Rolling-Mills.
Jeremiah Head, M. Inst. C.E.

A separate piece is introduced between the clutch and each clutch wheel, and connected with the latter only by elastic arms. The shock which ordinarily takes place when the clutch is thrown into gear is thus prevented.

2215a. Photograph of a Coal-testing Station.

2215b. Description of experiments on Coal relating to steam producing power; determination of the proper breadth for the spaces between the fire-bars, and treatment of the coal; ashes; weight per hectolitre; specific gravity and texture of the coal.
Berggewerkschaftskasse Bochum (Bergrath Heintzmann).

The coal experiment station is a central establishment for experiment on Westphalian coal, designed for giving exact scientific instruction as to the best uses of particular kinds of coal, and for ascertaining their comparative practical values.

2215c. Frisbie's Patent Feeder and Grate for feeding fuel up from underneath the fire into all descriptions of furnaces, fuel boxes, and fire grates, for saving fuel, securing an intense heat, and consuming the gas and smoke. *J. M. Holmes.*

This invention is designed for feeding fuel up from beneath the fire into furnaces and fire grates. No fuel is thrown upon the top of the fire, but into

a ... ch rocks forward to the front of the furnace under the grate ba..., when, upon turning a crank, a central shaft carries the charger back under a central opening in the grate, when a piston rises in the charger and pushes the fuel up underneath the burning mass above. When the piston rises level with the top surface of the charger, it is retained in place by a catch until a reverse motion of the crank brings the charger again to the front, when the catch releases the piston and the charger is again ready for filling, the previous charge of fuel being sustained by a movable apron. The grate is constructed to revolve, so that any melted coal or slag can be brought to the door and removed quickly.

By this method th ... tion ... coal is gradual, and the volatilised coal, combustible ga ... —d ... matter pass from below through the live coals above, and ... ... ame, and the greatest intensity of heat is secured, and the g... ... sumed and a great saving effected.

2216. Model of a ... **rnace Boiler,** upon elastic supports. *... eremiah Head, M. Inst. C.E.*

Long plain cylinder boilers, when ... s ordinarily upon rigid supports, are found to rise clear of the latter ... ir ends when in use, and in the middle when out of use. This leads ... m rips, and frequently explosion. By turning the small hand wheel ... r left, it will be seen that, by the method exhibited, the boiler is able t... ... fy its form without straining, and consequently without danger.

2216a. Model of a portion of the **Pontcysyllte Aqueduct,** which carries the Shropshire Union (late the Ellesmere) Canal across the river Dee, and the Vale of Llangollen. *G. R. Jebb.*

This model was made under the superintendence and direction of Telfords before the aqueduct was built. . . . The aqueduct consists of 19 arches, each having a span of 45 feet, the total length is 1,007 feet, and the height from the river Dee to the surface of the water in the canal is 127 feet. The foundation stone was laid on the 25th July 1795, and the work was finished in the year 1803.

This model having fallen into partial decay was a short time ago restored and repainted.

2216b. Model of an Apparatus for Exchanging Despatches on Railways, without Stoppage of the Trains.
M. Cacheleux, Paris.

2216c. Model of the late John Grantham's Patent Steam Tramway Car.

Also a detailed drawing of the above.
Mrs. John Grantham, Croydon.

2216d. Model Railway and Carriage, invented and made by Richard Roberts, C.E., Manchester, in 1824, to illustrate the nature of centrifugal force, in his lectures at the Manchester Mechanics' Institution. A practical model.
The Committee, Royal Museum, Peel Park, Salford.

X.—BRIDGE CONSTRUCTION.

2008. Diagrams for Bridge Construction :—

a. Resistances of materials, tension, and compression.
b. Girder on two supports.
c. Graphic treatment of arches for bridges.
d. Construction of iron bridges.
Prof. Heinzerling, Aix-la-Chapelle.

2009. Photographs for the study of Construction :—

a. Bauwaage (curves of construction), asymmetrical parabola.
b. Bauwaage (curves of construction), circle.
c. Bauwaage (curves of construction), segment of a circle.
d. Bauwaage (curves of construction), ellipse.
e. Bauwaage (curves of construction), aclinoid.
f. Bauwaage (curves of construction), cubic parabola—
as lines of equilibrium. *Prof. Heinzerling, Aix-la-Chapelle.*

2092. Model of a roof. *Bock and Handrick, Dresden.*

2093. Model of a bridge. *Bock and Handrick, Dresden.*

2098. Model of Bowstring Bridge, thrown over the canal at Wormwood Scrubs, the tunnel of the Great Western Railway passing under the canal. *Council of King's College, London.*

XI.—COLLECTION OF MODELS AND DIAGRAMS ILLUSTRATIVE OF THE PRINCIPLES OF MECHANICS, ROYAL SCHOOL OF MINES.

2217. Mr. Shelley's Educational Diagrams on the Steam Engine.

2218. Educational Diagrams for illustration of **Applied Mechanics.**

Reciprocating motion in bullet-making machine.
Cams for bullet-making machine.
Machine for shaping plugs for bullets.
Reversing motion in rifling machine (2).
A parallel motion applied for rolling under pressure.
Pulleys connected by belts.
Angle of repose for various substances.
Screw press.

D[illegible] crane.
Differential motion.
Train of wheelwork in a crane.
A crane.
The Whitworth measuring machine.
A lathe.
Headstock of lathe.
Train for screw-cutting lathe.
Drilling machine.
Planing machine (2).
Slide rest for face lathe.
Blanchard's lathe.
Other shaping machines (3).
Arrangements for advancing boring bar.
The Cordelier.
Clock train.
Chronometer.
Regulator of watch.
Going fuzee of watch.
Rack lever escapement.
Detached lever escapement.
Chronometer escapement.
Gravity escapement.
Compensation pendulum.
Siemens' steam jet and the pneumatic despatch tube.
Principle of Giffard's injector.
Mode of supplying water to trains while running.
Air-pump of the Allen steam engine.
Husband's atmospheric stamp.
Steam hammers.
Hydraulic ram.
Cast-iron girder beams (2).
Beam of steam engine, right and wrong construction.
Girder bridges (5).
Locomotive (2).
Cylindrical boiler (2).
Marine boiler.
Forms of rail and wheel tire for locomotive (2).
Indicator diagram and slide valve of locomotive.
Hornblower's double cylinder engine.
Double cylinder engine, with piston valves.
Watt's disc valve and connexions.
Fairbairn's equilibrium valve.
High-pressure cylinder, piston, and valves.
Mode of receiving thrust of screw propeller.
Gauge, with corrugated plate, and india-rubber diaphragm.
Pendulum governor (2).

Pendulum governor applied to water-wheel.
Siemens' chronometric governor.
The forge bellows.
Blowing fan, with gauge.
Guibal's ventilating fan.
Centrifugal pump.
Turbine.
Water-wheel.
Hydraulic press.
The accumulator.
Pump worked by water pressure.
Hydraulic cranes (5).
Water pressure engine (as for crane).
Press for squirting metals.

2219. Mr. Anderson's Educational Diagrams on Mechanics.

Levers (12).
Wheel and axle (18).
Pulley (8).
Inclined plane (8).
Wedge (8).
Screw (10).
Dynamometers (3).
Toggle joint.
Virtual velocities.
Hydraulic press.
Elastic cords.
Pumps (2).

2220. Model to show the Conversion of Circular into Reciprocating Motion, in one direction only.

2221. Model to show the Conversion of Circular into Reciprocating Motion, in two perpendicular directions.

2222. Model to show Inequality of Motion, when a crank and connecting rod are used; also that the linear motion may be doubled when the connecting rod is equal in length to the crank.

2223. Diagram Model, with parts to illustrate the movements when the connecting rod is equal to the crank. Straight line motion.

2224. Three Models of an Eccentric Circle.

2225. Model to show Conversion of Circular into Reciprocating Motion, with intervals of rest.

wo Models of Unbalanced Wheels.

2275. Model of an Arch.

2276. Model of Jointed Sword (Cowper).

2277. Model of Continuous Action Pump.

2278. Model of Pendulum, arranged for beating Time.

2279. Model fo [illegible] **ss Curves in the Slit Bar Motion.**

2280. Two Mo [illegible] **tric Rosette Motion.**

2281. Various Mod [illegible] **w the production of Measuring Bars for End m** [illegible]

2282. Model to illustra [illegible] **conversion of Linear into End measure.**

2283. Model to show Principle of Roberval's Balance.

2284. Balance on Roberval's Construction.

2285. Weighing Machine.

2286. Frame for experimenting with Epicyclic Trains, and with other trains, as in a screw-cutting lathe.

2287. Model of Combined Joints.

2288. Two forms of Ball and Socket Joint.

2289. Model of Hooke's Joint.

2290. Two Models of a Double Hooke's Joint, with adjustments.

2291. Mode of Connecting Parallel Axes.

2292. Parallel Axes, connected by a fork and grooved disc.

2293. Motion between Inclined Axes.

2294. Parallel Axes with Cranks and Links.

2295. Pair of Cranks, connected by a link, with adjustments.

2296. Mode of connecting Parallel Axes.

2297. Earliest Contrivance for feathering Floats in Paddle Wheels.

2298. Model of Link Motion in a Wool Combing Machine.

2299. Model of a Ventilating Fan.

2300. Model of Knuckle Joint.

2301. Knuckle Joint, with crank and connecting rod.

2302. Model of Stanhope Levers.

2303. Model of Lever Shears.

2304. Circular into Reciprocating Motion, with four beats for each rotation.

2305. Circular into Reciprocating Motion, with alternate intervals of rest.

2306. Model of Screw Surface.

2307. Model to show Difference of Inclination in Screw Threads of the same pitch, traced on cylinders of different diameters.

2308. Model of Endless Screw and Worm Wheel.

2309. Rolling Contact between Hyperboloids, with generating line mounted separately.

2310. Model of Skew Bevels.

2311. Two Axes, connected by a cord and grooved pulleys.

2312. Chain and Pulley.

2313. Pantograph, for drawing similar curves.

2314. Model of Watt's Parallel Motion.

2315. Model to illustrate the principle of Watt's Parallel Motion.

2316. Outline Model of Beam Engine, with Watt's parallel motion.

2317. Model of Roberts' Parallel Motion.

2318. Model of Peaucellier's Straight-line Motion.

2319. Sectional Model of a Trunk Engine.

2320. Model showing Expansion Valve.

el of Watt's Pendulum Governor.

2322. Model of the Cataract as applied to single-acting engines.

2323. Model of Silver's Marine Governor.

2324. Cornish Crown Valve.

2325. Hawthorn's Safety Valve.

2326. Richard's Indic

2327. Diagram Mod ing the Slide Valve of a Horizontal Engine.

2328. Mode of rev the Engine by a single eccentric.

2329. Model of Steph Link Motion.

2330. Model of Steam with Valve inside the Piston.

2331. Sectional diagram Model of the Pump.

2332. Giffard's Injector.

2333. Model of Slide Valve and Ports.

2334. Right and left handed Screw.

2335. Models to illustrate Ferguson's Paradox.

2336. Model to illustrate Silver's Marine Governor.

2337. Three Bevel Wheels forming Epicyclic Train.

2338. Model to explain the Differential Dynamometer.

2339. Differential Motion.

2340. A Geometrical Pen, showing application of an epicyclic train to the drawing of curves.

2341. Model to illustrate the principle of the Geometrical Pen.

2342. Model to illustrate Rope-making.

2343. The Cordelièr.

2344. Model of expanding and contracting Crank.

2345. Model of Differential Pulley (Saxton's Patent).

2346. Lazy Tongs.

2347. Model for generating a Cycloid.

2348. Model of Headstock of a Lathe.

2349. Model of Collier's Planing Machine.

350. Model of a Drilling Machine.

2351. Two Models illustrating Whitworth's Drilling Machine.

2352. Model of Eccentric Chuck.

2353. Model to illustrate Houldsworth's Differential Motion.

2354. Model of Screw Propellor.

2355. Model of a pair of Locomotive Wheels.

2356. Model of Hindley's Screw.

2357. Rolling contact between Ellipses.

2358. Elliptical Wheels, for obtaining a quick return in shaping machine.

2359. Variable motion from Wheels set eccentrically.

2360. Model of Roemer's Wheels.

2361. Method of altering or stopping the reciprocation of an Arm without stopping the prime mover.

2362. Model for comparing Bourdon's Gauge with Mercurial Pressure Gauge.

2363. Model to show principle of Bourdon's Gauge.

2364. Model of Wave Line Cam.

2365. Model of Heart Cam.

2366. Cam with Pulleys and Band.

2367. Model to illustrate Slit Bar Motion.

2368. Model of Spur Wheels.

2369. Model of Perrault's Wheel and Axle.

2370. Model of Blowing Fan.

2371. Model of Centrifugal Pump.

2372. Model of Screw.

2373. Model of Pump with revolving Belt.

odel to explain the Hydrostatic Press.

2375. Whirling Table for Suspended Objects.

2376. Models of Pyramid, Cone, Cylinder, Ring, Chain, and weighted piece, for experiments on rotation.

2377. Whirling Table.

2378. Model to show effect of Rotation on a cork and a bullet in tubes of water.

2379. Flask arr ... **eriments on Rotation.**

2380. Model to ... **ns' Water Governor.**

2381. Model to ... **bottom's Velocimeter.**

2382. Various Models sho ... **g effects due to Rotation.**

2383. Apparatus for showi ... he effect of the atmosphere in causing a spherical bullet to devi ... aterally.

2384. Balls swinging in ... **loid.**

2385. Models of Cone a ... **raboloid.**

2386. Two forms of Gyroscope.

2387. Model of Pendulum, with adjustments.

2388. Model of Accumulator, with Press.

2389. Sectional Model of Locomotive.

2390. Belt on Pulleys at right angles.

2391. Action of Convex Pulley on a Belt.

2392. Models to show the principle of Lattice Girder Beams.

2393. Whitworth's Bench Measuring Machine, to measure intervals differing by one ten thousandth of an inch, and for constructing difference gauges.

2394. Apparatus for obtaining a Rectangular Measuring Bar with plane ends at right angles to its axis.

2395. Hexagonal Surface Plates.

SECTION 13.—CHEMISTRY.

West Gallery, Upper Floor, Room (P).

I. MODELS, DIAGRAMS, APPARATUS, AND CHEMICALS EMPLOYED IN OR RÉSULTING FROM CHEMICAL RESEARCH.

2396. Apparatus employed by **John Dalton** in his **Researches.**

The Council of the Literary and Philosophical Society of Manchester.

The apparatus employed by John Dalton in his classical researches, whether physical or chemical, was of the simplest and even of the rudest character. Most of it was made with his own hands, and that which is exhibited has been chosen as illustrating this fact, and as indicating the genius which with so insignificant and incomplete an experimental equipment was able to produce such great results. The Society has in its possession a large quantity of apparatus used by Dalton, most of which however consists of electrical apparatus, models of mechanical powers, models of steam engines, air pumps, a Gregorian telescope, and other apparatus of a similar kind, which was either bought or presented to him. It has not been thought necessary to exhibit these, but rather to show the home-made apparatus with which Dalton obtained his most remarkable results.

I. *Meteorological and Physical Apparatus made and used by Dr. Dalton.*

Throughout his life Dalton devoted much time and attention to the study of meteorology; indeed his first work, published in 1793, was entitled "Meteorological Observations and Essays," and his last paper, printed in 1842,* (Mem. Lit. and Phil. Soc. VI. 617) consists of auroral observations. Hence the first of Dalton's apparatus which claim attention are the meteorological instruments.

No. 1 is Dalton's mountain barometer, with accompanying thermometer, made for him by the late Mr. Lawrence Buchan of Manchester. The barometer is enclosed in a wooden case, which Dalton was accustomed to carry in his hand.

Several home-made barometers used by Dalton in his observations are in possession of the Society. They are all of them filled, and the scales prepared, by Dalton himself, and are simple siphon tubes with a bulb blown on at the bottom to serve as a mercury reservoir. These are attached to plain pieces of deal, upon the upper part of which the paper scale is pasted. One of these, which has probably also served for tension experiments (No. 2), has been placed in the collection.

Many of the thermometers appear also to have been home-made.

No. 3 is a mercurial thermometer, evidently made and graduated by Dr. Dalton, and marked with his initials, J. D. The freezing point of this ther-

* *Vide* Life of Dalton by Dr. Henry, published by the Cavendish Society; Memoir of Dr. Dalton and the History of the Atomic Theory, published in the Memoirs of the Literary and Philosophical Society of Manchester, 2nd Series, Vol. I.; Dr. Lonsdale's Life of Dalton, Longmans, 1874.

m[illegible] ated recently by Mr. Baxendell, who found that it had not alt[illegible] instrument was graduated.

[illegible] (No. 4) is of the same kind, and bears the date 1823.

No. 5 is a third mercurial thermometer with long stem and wooden scale.

No. 6 is an alcohol thermometer with wooden scale.

No. 7 a registering maximum and minimum thermometer employed by Dalton; maker's name J. Ronchetti, 29, Balloon Street, Manchester

II. *Apparatus constructed and used by Dalton in his Researches.*

(1) "On the constitution of mi[illegible]" (2) "On the force of steam or "vapour from water or other [illegible]rent temperatures both in a Torri- "cellian vacuum and in air," [illegible]ation, and (4) "On the expansion "of gases by heat."*

No. 8 is an apparatus used [illegible] [illegible]ination of the tension of volatile liquids at low temperatures; [illegible] a siphon tube, at the upper end of which is a scale in inches in Dalton's [illegible]riting He describes it thus:

"I took a barometer tube 45 inc[illegible] [illegible]ength, and having sealed it hermetically at one end, bent it into [illegible] [illegible]hape, making the legs parallel, the end that was closed [illegible] the other 36 inches. I then conveyed two or three dr[illegible] [illegible]d of the closed leg, and filled the rest of the tube with mercury, [illegible] 10 inches at the open end. This done, I immersed the whole of th[illegible] [illegible] containing the ether into a tall glass containing hot water"

No 9 is a smaller tube containing another liquid, also having a graduated scale written on paper and attached to the tube.

Nos. 10, 11, 12, 13, 14, are tubes used by Dalton for measuring the tension of vapour from water and other liquids at higher temperatures than their boiling points, both in a vacuum and air.

No. 15 is a tube used by Dalton for measuring the tension of the vapour of bisulphide of carbon, labelled "Sulphuret carb.," with a paper scale in Dalton's handwriting, and a cork showing that the upper portion of the tube containing the bisulphide of carbon could be heated in a water bath to various temperatures.

No 16 is a manometer tube, fixed into a board, divided and numbered by Dalton.

No. 17 is an apparatus used by Dalton for the determination of the tension of the vapour of ether, and is interesting as being the instrument by means of which Dalton arrived at one of his most important experimental laws. It is described as follows (p. 564.):—

"The ether I used boiled in the open air at 102°. I filled a barometer tube with mercury moistened by agitation in ether; after a few minutes a portion of the ether rose to the top of the mercurial column, and the height of the column became stationary When the whole had acquired the temperature of the room (62°) the mercury stood at 17·00 inches, the barometer being at the same time 29·75 inches. Hence the force of the vapour from ether at 62° is equal to 12·74 of aqueous vapour at 172° temperature, which are 40° from the respective boiling points of the liquids."

This is generally known as Dalton's law of tensions, since shown by Regnault not to be rigorously true.

No 18 is a wet and dry bulb mercurial thermometer made by H. H. Watson, of Bolton.

* Experimental essays on the above subjects, by John Dalton, read October 2nd, 16th, and 30th, 1801, and published in the 1st series, vol. 5, part 2, of the Memoirs of the Literary and Philosophical Society of Manchester.

III. *Apparatus for Measuring Gases and for determining the Solubility of Gases in Water.*

No. 19 is an apparatus with a graduated tube, probably used by Dalton for the determination of the laws regulating "the absorption of gases by water "and other liquids," read October 21st, 1803. "Manchester Memoirs." 2nd Series. Vol. 1.

No. 20 is a graduated glass tube attached to a bottle of india-rubber, also probably used in his researches on the absorption of gases by water.

No. 21, No. 22, are divided eudiometer tubes, employed by Dalton for measuring the volumes of gases.

No. 23 is a spark eudiometer.

Nos. 24, 25, 26 are glass tubes, pipettes, and funnels graduated by Dr. Dalton and used by him for measuring gases.

No. 27 is a graduated glass bell-jar, used for measuring gases.

No. 28 is a phial, with graduated tube attached by cement, for collecting and measuring gases.

Nos. 29, 30 are stoppered phials, with the bottoms cut off, used as gas jars for collecting and measuring gases.

No. 31 is a thousand grains specific gravity bottle, with its counterpoise of lead stamped "175" by Dalton, and paper labelled in his handwriting 'bottle balance."

No. 32 is a pipette.

No. 33, square bottle of thin glass, fitted with brass caps, and probably used r the determination of the specific gravities of gases.

No. 34 is an earthenware cup, used by Dalton as a mercury-trough, and ntaining a small phial with mercury.

Nos. 35, 36 are bulb tubes, with graduated scales, serving for the determi- tion of the coefficients of expansion of gases.

No. 37 is a Florence flask with cork and valve for determining the specific vity of gases.

lo. 38 is a glass alembic.

Weights, Balances, Apparatus, Reagents, and Specimens used by Dalton.

). 39, eleven phials, containing creosote, iodine, amalgam of bismuth and ury, quercitron bark, grana sylvestra, cochineal, and other substances, ed in Dalton's handwriting.

. 40, three divided blocks, used by Dalton for the illustration of his lec- : these are not, however, the balls an inch in diameter (referred to in his memoir on the "Analysis of Sugar") which he employed occasionally lectures, as illustrating his newly-discovered laws of combination and mic theory; these appear, unfortunately, to be no longer in existence.

41 is a common pair of scales used by Dalton.

12. a pair of apothecary's scales and weights employed by Dalton, with of weights made of wire, labelled in his handwriting, "100th grains."

3 is a box of weights used by Dalton, and containing a pill box "Platina," another pill box labelled "Hund," and containing 100th , and another wooden box containing brass gramme weights, labelled ts, French;" the other ordinary weights are of lead.

is Dalton's pocket balance, consisting of a small pair of apothecaries' ith beam about 4 inches long, and having the pans attached by string; it is contained in a tin case for the pocket.

is a penholder used by Dalton.

leaden grain weights made by Dalton from sheet lead, and stamped s by him.

iron punches used by Dalton for this purpose.

… ss lens, wrapped in a piece of paper, labelled in Dalton's … focus 4·2 inches."

… a paper containing "10th of grains," made by Dr. Dalton of iron wire. The paper in which these are wrapped is part of a note from one of Dr. Dalton's pupils (as is well known, he lived by teaching mathematics at half-a-crown per lesson), in which the writer presents his "complements to "Mr. Dalton, and is sorry that he will not be able to wait upon him to-day, "as he is going to Liverpool with a few friends who are trying the railway "for the first time. Mr. D. may fully expect him on Monday at the usual "time."

No. 50 are bottles of tin, earthenware and silver, some of them being common penny po… bottles. E… thermometer tube cemented into the neck of the bottle… ese t… ovided with paper scales. These were used by Dalton … y fo… ts on radiant heat.

No. 51 is a manometer … lton; it consists of a tin vessel attached on either side to … and having a thermometer-tube closed at the upper end, a… a divided scale, fixed into the upper portion of the tin vessel.

No. 52, Dalton's Balance, made by A… n, and capable of arrangement as hydrostatic-balance with weights and … rpoises.

2398. Balance used by … sh.

… Institution of Great Britain.

This balance, of rude exterior but ex… r perfection, was made by Harrison according to the plan and by order … enry Cavendish, Esq., and passed at his death to his cousin and heir, Lord George Cavendish. By him it was presented to Sir Humphry Davy, together with the greater part of Mr. Cavendish's philosophical apparatus. Presented to the Royal Institution of Great Britain by Mr. Felix R. Garden.

2399. Balance used by **Dr. Thomas Young** and **Sir Humphry Davy.** *The Royal Institution of Great Britain.*

A balance made by Fidler for the Royal Institution, nearly resembling those of Ramsden and Troughton. "Lectures on Natural Philosophy," by Thomas Young, M.D., 1807. "Works of Sir Humphery Davy," vol. 5, page 17.

2400. Balance used by **Sir Humphry Davy.** Presented to Professor Roscoe by Mrs. F. Crace-Calvert.

Professor Roscoe, F.R.S.

2401. Balance used in his experiments by Dr. Joseph Black, Professor of Chemistry in the University of Edinburgh, from 1766 to 1799. Dr. Black was the discoverer of fixed air (carbonic acid), and author of the theory of latent heat.

Edinburgh Museum of Science and Art.

2401a. Balance used by, or formerly belonging to, Dr. Priestley. *William Sykes Ward.*

This is remarkable as a good specimen of early work, having friction pulleys for suspending the beam; also an interchangeable piece with steel planes, gearing for raising the beam concealed in foot, extra pans and glass bucket for taking specific gravities. The successive owners of the balance are believed to have been: Dr. Priestley (Leeds), Abraham Sharpe (Bradford), Joshua Muff (Leeds), and the Exhibitor.

2402. Plattner's Diamond Mortar, in steel.
No. 1, with brass capsule.
No. 2, without „
No. 3, „ „ *A. Herbst, Berlin.*

2403. Freyberg's Diamond Mortar, in steel.
No. 1, with brass capsule.
No. 2, without „
No. 3, „ „ *A. Herbst, Berlin.*

2405. Faraday's Apparatus for the **Condensation** and **Liquefaction** of **Gases.**
The Royal Institution of Great Britain.

Apparatus used by Faraday for the condensation and liquefaction of gases, consisting of condensing pump and connexions, conducting and other tubes, gauges, sealed tubes for containing the liquefied gases, &c. &c.—Phil. Trans. 1845.

2406. Original Tubes containing Gases liquefied by Faraday. *The Royal Institution of Great Britain.*

1.–5. Muriatic Acid.
6. Carbonic Acid.
7. Nitrous Oxide.
8. Sulphurous Acid.
9.–10. Cyanogen.
11. Ammonia.
(Phil. Trans. 1845.)
12. Arseniuretted Hydrogen.
13. Ammonia.
14.–15. Hydrobromic Acid.
16. Chlorine.
17.–18. Chlorine and Sulph. Acid.
19. Sulphuretted Hydrogen.
20. Hydriodic Acid.
21. Arseniuretted Hydrogen.

2407. Apparatus by which Dr. Andrews and Professor Tait proved that ozone is a condensed form of oxygen.
Dr. Andrews, F.R.S.

Dry oxygen gas is exposed to the action of the silent electrical discharge in a glass tube terminating in a U tube containing sulphuric acid, which indicates by its change of position the change of volume in the gas.

2408. Apparatus for exhibiting in the lecture room the contraction which takes place when oxygen is changed into ozone. It is formed of a modified Siemen's tube: the contraction being shown by the ascent of the sulphuric acid in which the open end of the tube is immersed. *Dr. Andrews, F.R.S.*

2409. Apparatus used for ascertaining the **Density of Ozone.** *Mr. J. Louis Soret, Geneva.*

This process, based upon the velocity of diffusion, has been described in detail in the "Recherches sur le Densité de l'Ozone" (Archives des Sciences physiques et naturelles, 1867, Vol. 30, p. 328. Annales de Chimie et de physique, 1868, Vol. 13, p. 264). Constructed by the Geneva Association for the Construction of Scientific Instruments.

2409a. Original Apparatus, by M. Dumas, for ascertaining the density of gases. *M. J. Dumas, Paris.*

24191. Specimens of Native Antimony.

George Gore, F.R.S.

2421. Pseudo-crystal of **Native Ceylon Graphite. Bar** of extremely pure **metallic Tellurium,** weighing 2,000 grains.

George Gore, F.R.S.

2423. Mercury Distilling Apparatus, constructed according to Dr. A. Weinhold's system.

T. Bosscha, Professor, Royal Polytechnic School, Delft.

(Carl's Repertorium der Physi . . . , p. 69), with slight modifications of the mercury reservoirs, giving . . . r about 500 grammes of distilled mercury, constructed by M. M. E . . . and Sons, Delft.

2425. The **Original A . . . ery.**

. . . Gladstone and Alfred Tribe.

When a plate of copper is . . . th metallic silver, and immersed in a solution of copper nitrate, th . . . he air dissolved in the liquid takes part in the re-action, the copper is eaten away, and cuprous oxide is deposited upon the silver. This gives rise to the ordinary voltaic phenomena.

2426. The **Original Cop . . . inc Couple.** A.D. 1871.

J. . . . Gladstone and Alfred Tribe.

This consists of coils of sheet-zinc on which copper has been deposited in a finely divided condition, by pouring copper sulphate upon them, and washing away the salt produced. In this case the coils are separated by layers of muslin. The couple having been immersed in water, has decomposed it, and the zinc is now thoroughly oxidized.

2427. The **Original Copper-zinc Couple** of the present arrangement. *J. H. Gladstone and Alfred Tribe.*

In this case the zinc foil is crumpled, and covered with the deposited copper. The zinc is now completely covered with oxide through the decomposition of water.

2428. Tubes showing that the hydrogen prepared from water by the copper-zinc couple does not contain arsenic, though the zinc is so greatly contaminated with arsenic as to give much arseniuretted hydrogen when dissolved in acid.

J. H. Gladstone and Alfred Tribe.

2429. Original Specimens of Ethylo-bromide of Zinc, and **Ethylo-chloride of Zinc,** substances prepared by means of the copper-zinc couple. *J. H. Gladstone and Alfred Tribe.*

2430. Essential Oils and their derivatives. *J. H. Gladstone.*

1. Menthene. An oil of the C_{10} H_{18} group.
2. Cedrene. An oil of the C_{15} H_{24} group.
3. Hydrosulphate of menthole.
4. Hydrate of oil of turpentine. C_{10} H_{16}, $3H_2O$.
5. The same recrystallized from water.
6. Cœruleine, a deep blue colouring matter found in the essential oils of Matricaria Chamomilla, Artemisia Absinthium, and several others of the C_{15} H_{24} group.

2430a. Specimens of **Chemicals illustrating Researches** on :—

1. The transformation of cyanogen (CN) into oxatyl (COHo).
2. Polymerisation of ethylic cyanide.
3. The isolation of the organic radicals.
4. Organo-metallic bodies.
5. The substitution of $'N_2''$ for C^{iv} in organic compounds.
6. Organo-boron compounds.
7. The synthesis of ethers, acids of the acetic series, and ketones.
8. The synthesis of acids of the lactic series.
9. The synthesis of acids of the acrylic series.

E. Frankland, F.R.S.

I.—Transformation of Cyanogen (CN) into Oxatyl (COHo) Inorganic Compounds.—(Kolbe & Frankland.)

1. Acetic acid $\left(\left\{\begin{matrix}CH_3\\ COHo\end{matrix}\right.\right)$ made from β methylic cyanide $\left(\left\{\begin{matrix}CH_3\\ CN\end{matrix}\right.\right)$.

2. Argentic acetate $\left(\left\{\begin{matrix}CH_3\\ COAgo\end{matrix}\right.\right)$ made from the above acid.

3. Propionic acid $\left(\left\{\begin{matrix}CMeH_2\\ COHo\end{matrix}\right.\right)$ made from β ethylic cyanide $\left(\left\{\begin{matrix}CMeH_2\\ CN\end{matrix}\right.\right)$.

The following salts made from this acid :—

4. Argentic propionate $\left(\left\{\begin{matrix}CMeH_2\\ COAgo\end{matrix}\right.\right)$.

5. Baric propionate $\left.\begin{matrix}\left\{\begin{matrix}CMeH_2\\ CO\end{matrix}\right.\\ \left\{\begin{matrix}CO\\ CMeH_2\end{matrix}\right.\end{matrix}\right.Bao''$.

6. Plumbic propionate $\left.\begin{matrix}\left\{\begin{matrix}CMeH_2\\ CO\end{matrix}\right.\\ \left\{\begin{matrix}CO\\ CMeH_2\end{matrix}\right.\end{matrix}\right.Pbo''$.

7. Caproic acid $\left(\left\{\begin{matrix}CBuH_2\\ COHo\end{matrix}\right.\right)$ made from β amylic cyanide $\left\{\begin{matrix}CBuH_2\\ CN\end{matrix}\right.$.

The following salts made from this acid :—

8. Argentic caproate $\left\{\begin{matrix}CBuH_2\\ COAgo\end{matrix}\right.$.

9. Baric caproate $\left.\begin{matrix}\left\{\begin{matrix}CBuH_2\\ CO\end{matrix}\right.\\ \left\{\begin{matrix}CO\\ CBuH_2\end{matrix}\right.\end{matrix}\right.Bao''$.

II.—Polymerisation of Ethylic Cyanide.—(Kolbe & Frankland.

1. Cyanethine $^{vi}(N_3)^{ix}$ $(CEt)'''_3$.
2. Cyanethine nitrate $NO_2(N_3C_9H_{16}O)$.
3. Cyanethine oxalate $\left\{\begin{matrix}CO(N_3C_9H_{16}O)\\ CO(N_3C_9H_{16}O)\end{matrix}\right.$.
4. Cyanethine platinic chloride $2N_3C_9H_{16}Cl, PtCl_4$.

[I]SOLATION OF THE ORGANIC RADICALS.—(Frankland.)

1. Methyl $\left\{\begin{matrix} CH_3 \\ CH_3 \end{matrix}\right.$ or Me_2.
2. Ethyl $\left\{\begin{matrix} CMeH_2 \\ CMeH_2 \end{matrix}\right.$ or Et_2.
3. Ethylic hydride $CMeH_3$ or EtH.
4. Amyl $\left\{\begin{matrix} CBuH_2 \\ CBuH_2 \end{matrix}\right.$ or Ay_2.
5. An[...] $CBuH_3$ or AyH.
6. [...] which ethyl was first analysed.

IV.—ORGANO-METALLIC BODIES.—(Frankland).

1.	Zincic methide	$ZnMe_2$.
2.	Zincic ethide	$ZnEt_2$.
3.	Zincic ethylate	$ZnEto_2$.
4.	Zincic amylide	$ZnAy_2$.
5.	Stannous ethide	$SnEt_2$.
6.	Stannic ethide	$SnEt_4$.
7.	Stannic ethylo-dimethide	$SnEt_2Me_2$.
8.	Stannic dichlorethide	$SnEt_2Cl_2$.
9.	Stannic iodo-diethide	$SnEt_2I_2$.
10.	Stannic bromo-triethide	$SnEt_3Br$.
11.	Distannic iodo tetrethide	$Sn_2Et_4I_2$.
12.	Mercuric methide	$HgMe_2$.
13.	Mercuric iodomethide	$HgMeI$.
14.	Mercuric chlormethide	$HgMeCl$.
15.	Mercuric ethide	$HgEt_2$.
16.	Mercuric chlorethide	$HgEtCl$.
17.	Mercuric amylide	$HgAy_2$.
18.	Mercuric chloramylide	$HgAyCl$.
19.	Mercuric iodoamylide	$HgAyI$.

V.—THE SUBSTITUTION OF 'N_2'' FOR C^{iv} IN ORGANIC COMPOUNDS.—(Frankland.)

1. Ethylozincic dinitroethylate $N_2EtO(OZnEt)$.
2. Zincic dinitroethylate $\begin{matrix} N_2EtO \\ N_2EtO \end{matrix} Zno''$ analogous to zincic propionate $\begin{matrix} CEtO \\ CEtO \end{matrix} Zno''$.
3. Calcic dinitroethylate $\begin{matrix} N_2EtO \\ N_2EtO \end{matrix} Cao''$ analogous to calcic propionate $\begin{matrix} CEtO \\ CEtO \end{matrix} Cao''$.
4. Baric dinitroethylate $\begin{matrix} N_2EtO \\ N_2EtO \end{matrix} Bao''$.
5. Magnesic dinitroethylate $\begin{matrix} N_2EtO \\ N_2EtO \end{matrix} Mgo''$.
6. Cupric dinitroethylate $\begin{matrix} N_2EtO \\ N_2EtO \end{matrix} Cuo''$.
7. Sodic dinitroethylate $N_2EtONaO$ analogous to sodic propionate $CEtONao$.

VI.—Organo-boron Compounds.—(Frankland.)

1. Boric methide BMe_3.
2. Ammonia-boric methide NH_3, BMe_3.
3. Boric ethide BEt_3.
4. Ammonia boric ethide NN_3, BEt_3.
5. Boric etho-diethylate $BEtEto_2$.
6. Boric etho-dihydrate $BEtHo_2$.

VII.—Synthesis of Ethers, Acids of the Acetic Series and Ketones.—(Frankland & Duppa.)

Ethers.

1. Ethylic methaceto-acetate $C_7H_{12}O_3$ or $\left\{\begin{array}{l} COMe \\ CMeH. \\ COEto \end{array}\right.$

2. Ethylic dimethaceto-acetate $C_8H_{14}O_3$ or $\left\{\begin{array}{l} COMe \\ CMe_2. \\ COEto \end{array}\right.$

3. Ethylic ethaceto-acetate $C_8H_{14}O_3$ or $\left\{\begin{array}{l} COMe \\ CEtH. \\ COEto \end{array}\right.$

4. Ethylic diethaceto-acetate $C_{10}H_{18}O_3$ or $\left\{\begin{array}{l} COMe \\ CEt_2. \\ COEto \end{array}\right.$

5. Ethylic isopropaceto-acetate $C_9H_{16}O_3$ or $\left\{\begin{array}{l} COMe \\ C\beta PrH. \\ COEto \end{array}\right.$

6. Ethylic dimethacetate (isobutyrate) $C_6H_{12}O_2$ or $\left\{\begin{array}{l} CMe_2H \\ COEto \end{array}\right.$.

7. Ethylic ethacetate (butyrate) $C_6H_{12}O_2$ or $\left\{\begin{array}{l} CEtH_2 \\ COEto \end{array}\right.$.

8. Ethylic diethacetate (isocaproate) $C_8H_{16}O_2$ or $\left\{\begin{array}{l} CEt_2H \\ COEto \end{array}\right.$.

9. Ethylic isopropacetate (isovalerate) $C_7H_{14}O_2$ or $\left\{\begin{array}{l} C\beta PrH_2 \\ COEto \end{array}\right.$.

10. Ethylic amylacetate (œnanthylate) $C_9H_{18}O_2$ or $\left\{\begin{array}{l} CAyH_2 \\ COEto \end{array}\right.$.

Acids and their Salts.

1. Dimethacetic acid (isobutyric acid) $C_4H_8O_2$ or $\left\{\begin{array}{l} CMe_2H \\ COHo \end{array}\right.$.

2. Argentic dimethacetate $C_4H_7AgO_2$ or $\left\{\begin{array}{l} CMe_2H \\ COAgo \end{array}\right.$.

3. Ethacetic acid (butyric acid) $C_4H_8O_2$ or $\left\{\begin{array}{l} CEtH_2 \\ COHo \end{array}\right.$.

4. Argentic ethacetate $C_4H_7AgO_2$ or $\left\{\begin{array}{l} CEtH_2 \\ COAgo \end{array}\right.$.

5. Diethacetic acid (isocaproic acid) $C_6H_{12}O_2$ or $\left\{\begin{array}{l} CEt_2H \\ COHo \end{array}\right.$.

...ntic diethacetate $C_6H_{11}AgO_2$ or $\left\{\begin{matrix} CEt_2H \\ COAgo \end{matrix}\right.$.

7. Baric diethacetate $C_{12}H_{22}BaO_4$ or $\left\{\begin{matrix} CEt_2H \\ CO \\ CO \\ CEt_2H \end{matrix}\right.$ Bao''.

8. Isopropacetic acid (isovaleric acid) $C_5H_{10}O_2$ or $\left\{\begin{matrix} C\beta PrH_2 \\ COHo \end{matrix}\right.$.

9. Arge... $C_5H_9AgO_2$ or $\left\{\begin{matrix} C\beta PrH_2 \\ COAgo \end{matrix}\right.$.

10. Amylacetic acid (œna... ...lic acid) $C_7H_{14}O_2$ or $\left\{\begin{matrix} CAyH_2 \\ COHo \end{matrix}\right.$.

11. Argentic amylacetate $C_7H_{13}AgO_2$ or $\left\{\begin{matrix} CAyH_2 \\ COAgo \end{matrix}\right.$.

12. Baric amylacetate $C_{14}H_{26}BaO_4$ or $\left\{\begin{matrix} CAyH_2 \\ CO \\ CO \\ CAyH_2 \end{matrix}\right.$ Bao''.

Ketones.

1. Methylated acetone C_4H_8O or $\left\{\begin{matrix} COMe \\ CMeH_2 \end{matrix}\right.$.
2. Dimethylated acetone $C_5H_{10}O$ or $\left\{\begin{matrix} COMe \\ CMe_2H \end{matrix}\right.$.
3. Ethylated acetone $C_5H_{10}O$ or $\left\{\begin{matrix} COMe \\ CEtH_2 \end{matrix}\right.$.
4. Diethylated acetone $C_7H_{14}O$ or $\left\{\begin{matrix} COMe \\ CEt_2H \end{matrix}\right.$.
5. Isopropylated acetone $C_6H_{12}O$ or $\left\{\begin{matrix} COMe \\ C\beta PrH_2 \end{matrix}\right.$.

VIII.—SYNTHESIS OF ACIDS OF THE LACTIC SERIES.—(Frankland & Duppa.)

1. Dimethoxalic acid $C_4H_8O_3$ or $\left\{\begin{matrix} CMe_2Ho \\ COHo \end{matrix}\right.$.
2. Argentic dimethoxalate $C_4H_7AgO_3$ or $\left\{\begin{matrix} CMe_2Ho \\ COAgo \end{matrix}\right.$.
3. Baric dimethoxalate $C_8H_{14}BaO_6$ or $\left\{\begin{matrix} CMe_2Ho \\ CO \\ CO \\ CMe_2Ho \end{matrix}\right.$ Bao''.
4. Ethomethoxalic acid $C_5H_{10}O_3$ or $\left\{\begin{matrix} CEtMeHo \\ COHo \end{matrix}\right.$.
5. Argentic ethomethoxalate $C_5H_9AgO_3$ or $\left\{\begin{matrix} CEtMeHo \\ COAgo \end{matrix}\right.$.

ylic ethomethoxalate	$C_7H_{14}O_3$	or $\left\{\begin{array}{l}\mathrm{CEtMeHo}\\\mathrm{COEto}\end{array}\right.$.
ic ethomethoxalate	$C_{10}H_{18}BaO_6$	or $\begin{array}{l}\left\{\begin{array}{l}\mathrm{CEtMeHo}\\\mathrm{CO}\end{array}\right.\\\left\{\begin{array}{l}\mathrm{CO}\\\mathrm{CEtMeHo}\end{array}\right.\end{array}\mathrm{Bao''}$.
thoxalic acid	$C_6H_{12}O_3$	or $\left\{\begin{array}{l}\mathrm{CEt_2Ho}\\\mathrm{COHo}\end{array}\right.$.
gentic diethoxalate	$C_6H_{11}AgO_3$	or $\left\{\begin{array}{l}\mathrm{CEt_2Ho}\\\mathrm{COAgo}\end{array}\right., \frac{1}{2}\mathrm{OH_2}$.
hylic diethoxalate	$C_7H_{14}O_3$	or $\left\{\begin{array}{l}\mathrm{CEt_2Ho}\\\mathrm{COMeo}\end{array}\right.$.
ylic diethoxalate	$C_8H_{16}O_3$	or $\left\{\begin{array}{l}\mathrm{CEt_2Ho}\\\mathrm{COEto}\end{array}\right.$.
ylic diethoxalate	$C_{11}H_{22}O_3$	or $\left\{\begin{array}{l}\mathrm{CEt_2Ho}\\\mathrm{COAyo}\end{array}\right.$.
ic diethoxalate	$C_{12}H_{22}BaO_6$	or $\begin{array}{l}\left\{\begin{array}{l}\mathrm{CEt_2Ho}\\\mathrm{CO}\end{array}\right.\\\left\{\begin{array}{l}\mathrm{CO}\\\mathrm{CEt_2Ho}\end{array}\right.\end{array}\mathrm{Bao''}$.
pric diethoxalate	$C_{12}H_{22}CuO_6$	or $\begin{array}{l}\left\{\begin{array}{l}\mathrm{CEt_2Ho}\\\mathrm{CO}\end{array}\right.\\\left\{\begin{array}{l}\mathrm{CO}\\\mathrm{CEt_2Ho}\end{array}\right.\end{array}\mathrm{Cuo''}$.
cic diethoxalate	$C_{12}H_{22}ZnO_6$	or $\begin{array}{l}\left\{\begin{array}{l}\mathrm{CEt_2Ho}\\\mathrm{CO}\end{array}\right.\\\left\{\begin{array}{l}\mathrm{CO}\\\mathrm{CEt_2Ho}\end{array}\right.\end{array}\mathrm{Zno''}$.
hylic zincmonethyl diethoxalate	$C_{10}H_{20}ZnO_3$	or $\left\{\begin{array}{l}\mathrm{CEt_2(OZnEt)}\\\mathrm{COEto}\end{array}\right.$.
nylhydroxalic acid	$C_7H_{14}O_3$	or $\left\{\begin{array}{l}\mathrm{CAyHHo}\\\mathrm{COHo}\end{array}\right.$.
hylic amylhydroxalate	$C_9H_{18}O_3$	or $\left\{\begin{array}{l}\mathrm{CAyHHo}\\\mathrm{COEto}\end{array}\right.$.
lcic amylhydroxalate	$C_{14}H_{26}CaO_6$	or $\begin{array}{l}\left\{\begin{array}{l}\mathrm{CAyHHo}\\\mathrm{CO}\end{array}\right.\\\left\{\begin{array}{l}\mathrm{CO}\\\mathrm{CAyHHo}\end{array}\right.\end{array}\mathrm{Cao''}$.
ric amylhydroxalate	$C_{14}H_{26}BaO_6$	or $\begin{array}{l}\left\{\begin{array}{l}\mathrm{CAyHHo}\\\mathrm{CO}\end{array}\right.\\\left\{\begin{array}{l}\mathrm{CO}\\\mathrm{CAyHHo}\end{array}\right.\end{array}\mathrm{Bao''}$.
pric amylhydroxalate	$C_{14}H_{26}CuO_6$	or $\begin{array}{l}\left\{\begin{array}{l}\mathrm{CAyHHo}\\\mathrm{CO}\end{array}\right.\\\left\{\begin{array}{l}\mathrm{CO}\\\mathrm{CAyHHo}\end{array}\right.\end{array}\mathrm{Cuo''}$.
nylethoxalic acid	$C_9H_{18}O_3$	or $\left\{\begin{array}{l}\mathrm{CAyEtHo}\\\mathrm{COHo}\end{array}\right.$.

23. [illegible]mylethoxalate	$C_9H_{17}AgO_3$	or	$\left\{\begin{array}{l}\mathrm{CAyEtHo}\\ \mathrm{COAgo}\end{array}\right.$.
24. Ethylic amylethoxalate	$C_{11}H_{22}O_3$	or	$\left\{\begin{array}{l}\mathrm{CAyEtHo}\\ \mathrm{COEto}\end{array}\right.$.
25. Baric amylethoxalate	$C_{18}H_{34}BaO_6$	or	$\begin{array}{l}\left\{\begin{array}{l}\mathrm{CAyEtHo}\\ \mathrm{CO}\end{array}\right.\\ \left\{\begin{array}{l}\mathrm{CO}\\ \mathrm{CAyEtHo}\end{array}\right.\end{array}\mathrm{Bao'}$.
26. Diamyloxalic acid	$C_{12}H_{24}O_3$	or	$\left\{\begin{array}{l}\mathrm{CAy_2Ho}\\ \mathrm{COHo}\end{array}\right.$.
27. Ethylic diamyloxalate	$C_{14}H_{28}O$	or	$\left\{\begin{array}{l}\mathrm{CAy_2Ho}\\ \mathrm{COEto}\end{array}\right.$.
28. Amylic diamyloxalate	$C_{17}H_{34}O_3$	or	$\left\{\begin{array}{l}\mathrm{CAy_2Ho}\\ \mathrm{COAyo}\end{array}\right.$.
29. Baric diamyloxalate	$C_{24}H_{46}BaO_6$	or	$\begin{array}{l}\left\{\begin{array}{l}\mathrm{CAy_2Ho}\\ \mathrm{CO}\end{array}\right.\\ \left\{\begin{array}{l}\mathrm{CO}\\ \mathrm{CAy_2Ho}\end{array}\right.\end{array}\mathrm{Bao''}$.

IX.—Synthesis of Acids of the Acrylic Series.—(Frankland & Duppa.)

1. Methacrylic acid	$C_4H_6O_2$	or	$\left\{\begin{array}{l}\mathrm{CMe''Me}\\ \mathrm{COHo}\end{array}\right.$.
2. Argentic methacrylate	$C_4H_5AgO_2$	or	$\left\{\begin{array}{l}\mathrm{CMe''Me}\\ \mathrm{COAgo}\end{array}\right.$.
3. Ethylic methacrylate	$C_6H_{10}O_2$	or	$\left\{\begin{array}{l}\mathrm{CMe''Me}\\ \mathrm{COEto}\end{array}\right.$.
4 Baric methacrylate	$C_8H_{10}BaO_4$	or	$\begin{array}{l}\left\{\begin{array}{l}\mathrm{CMe''Me}\\ \mathrm{CO}\end{array}\right.\\ \left\{\begin{array}{l}\mathrm{CO}\\ \mathrm{CMe''Me}\end{array}\right.\end{array}\mathrm{Bao'}$.
5. Cupric methacrylate	$C_8H_{10}CuO_4$	or	$\begin{array}{l}\left\{\begin{array}{l}\mathrm{CMe''Me}\\ \mathrm{CO}\end{array}\right.\\ \left\{\begin{array}{l}\mathrm{CO}\\ \mathrm{CMe''Me}\end{array}\right.\end{array}\mathrm{Cuo''}$.
6. Methyl-crotonic acid	$C_5H_8O_2$	or	$\left\{\begin{array}{l}\mathrm{CEt''Me}\\ \mathrm{COHo}\end{array}\right.$.
7. Argentic methyl-crotonate	$C_5H_7AgO_2$	or	$\left\{\begin{array}{l}\mathrm{CEt''Me}\\ \mathrm{COAgo}\end{array}\right.$.
8. Ethylic methyl-crotonate	$C_7H_{12}O_2$	or	$\left\{\begin{array}{l}\mathrm{CEt''Me}\\ \mathrm{COEto}\end{array}\right.$.
9. Baric methyl-crotonate	$C_{10}H_{14}BaO_4$	or	$\begin{array}{l}\left\{\begin{array}{l}\mathrm{CEt''Me}\\ \mathrm{CO}\end{array}\right.\\ \left\{\begin{array}{l}\mathrm{CO}\\ \mathrm{CEt''Me}\end{array}\right.\end{array}\mathrm{Bao''}$.
10. Ethyl-crotonic acid	$C_6H_{10}O_2$	or	$\left\{\begin{array}{l}\mathrm{CEt''Et}\\ \mathrm{COHo}\end{array}\right.$.
11. Potassic ethyl-crotonate	$C_6H_9KO_2$	or	$\left\{\begin{array}{l}\mathrm{CEt''Et}\\ \mathrm{COKo}\end{array}\right.$.

12. Argentic ethyl-crotonate . $C_6H_9AgO_2$ or $\left\{\begin{matrix} \text{CEt}''\text{Et} \\ \text{COAgo} \end{matrix}\right.$.

13. Ethylic ethyl-crotonate $C_8H_{14}O_2$ or $\left\{\begin{matrix} \text{CEt}''\text{Et} \\ \text{COEto} \end{matrix}\right.$.

14. Cupric ethyl-crotonate $C_{12}H_{18}CuO_4$ or $\left\{\begin{matrix} \text{CEt}''\text{Et} \\ \text{CO} \end{matrix}\right. \text{Cuo}'' \left\{\begin{matrix} \text{CO} \\ \text{CEt}''\text{Et} \end{matrix}\right.$.

15. Plumbic ethyl-crotonate $C_{12}H_{18}PbO_4$ or $\left\{\begin{matrix} \text{CEt}''\text{Et} \\ \text{CO} \end{matrix}\right. \text{Pbo}'' \left\{\begin{matrix} \text{CO} \\ \text{CEt}''\text{Et} \end{matrix}\right.$.

2536. Specimens of Chemicals, illustrating some of W. H. rkin's researches in organic chemistry.

W. H. Perkin, F.R.S.

[. On the action of chloride of cyanogen on naphthylamine.
I. On the action of bromine on acetic acid and artificial formaa of glycocol. (Perkin and Duppa.)
[II. On the action of bromine on bromacetic acid. (Perkin and Duppa.)
IV. On dibromosuccinic acid, and the artificial production of taric acid. (Perkin and Duppa.)
V. On azodinaphthyldiamin. (Perkin and Church.)
VI. On mauve or aniline purple.
VII. On the basicity of tartaric acid.
VIII. On some derivatives of the hydride of salicyl.
X. On the action of acetic anhydride on the hydride of salicyl.
X. On the artificial production of coumarin and its homologues.
XI. On some new derivatives of coumarin.
XII. On chlorinated chloride of methyl.
XIII. On some derivatives of anthracene.
XIV. On artificial alizarin.
XV. On bromo-alizarin.
XVI. On nitro-alizarin.
XVII. On anthrapurpurin.
XVIII. On anthraflavic acid.
XIX. On the formation of anthrapurpurin.
XX. On glyoxylic acid.

I.

Menaphthylamine (carbodinaphthyltriamine) $C_{21}H_{17}N_3$, product of the ction of chloride of cyanogen on naphthylamine $C_{10}H_9N$.

II.

Bromacetic acid $C_2H_3BrO_2 = \begin{array}{l} CO(OH) \\ | \\ CH_2Br \end{array}$

" ether $C_4H_7BrO_2 = \begin{array}{l} CO(OEt) \\ | \\ CH_2Br. \end{array}$

(Perkin and Duppa.)

III.

Dibromacetic acid $C_2H_2Br_2O_2 = \begin{array}{l} CO(OH) \\ | \\ CHBr_2 \end{array}$

Dibromacetamide $C_2H_3Br_2NO = \begin{array}{l} CO-NH_2 \\ | \\ CHBr_2. \end{array}$

(Perkin and Duppa.)

IV.

Dibromosuccinic acid $C_4H_4Br_2O_4 = \begin{array}{l} CO(OH) \\ | \\ C_2H_2Br_2 \\ | \\ CO(OH) \end{array}$ prepared from the chloride of dibromosuccinyl.

Tartaric acid (inactive) $C_4H_6O_6, H_2O = \begin{array}{l} CO(OH) \\ | \\ C_2H_2(OH)_2 \\ | \\ CO(OH) \end{array}$ obtained by boiling argentic dibromosuccinate with water.

(Perkin and Duppa.)

V.

Azodinaphthyldiamin $C_{20}H_{15}N_3 = \left\{ \begin{array}{l} (C_{10}H_7)_2) \\ N''' \\ H \end{array} \right\} N_2.$

(Perkin and Church.)

VI.

Mauveine		$C_{27}H_{24}N_4.$
"	hydrochlorate	$C_{27}H_{24}N_4$—Cl.
"	sulphate	$(C_{27}H_{24}N_4)_2H_2SO_4.$
"	nitrate	$C_{27}H_{24}N_4HNO_3.$
"	hydriodate	$C_{27}H_{24}N_4HI.$
"	carbonate	$C_{27}H_{24}N_4H_2CO_3$?

VII.

Diacetotartaric ether $C_{12}H_{18}O_8 = \begin{array}{l} CO(OEt) \\ | \\ C_2H_2 \left\{ \begin{array}{l} (OAc) \\ (OAc) \end{array} \right. \\ | \\ CO(OEt). \end{array}$

Diacetoparatartaric ether, do. do.

$$\text{rtaric anhydride } C_8H_8O_8 = \begin{matrix} CO \\ | \\ C_2H_2\left\{\begin{matrix}(OAc)\\(OAc)\end{matrix}\right\}O \\ | \\ CO \end{matrix} \; O$$

$$\text{aric ether } C_{15}H_{18}O_7 = \begin{matrix} CO(OEt) \\ | \\ C_2H_2\left\{\begin{matrix}(OBz)\\(OH)\end{matrix}\right. \\ | \\ CO(OEt) \end{matrix}$$

$$\text{zotartaric ether } C_{17}H_{20}O_8 = \begin{matrix} CO(OEt) \\ | \\ C_2H_2\left\{\begin{matrix}(OBz)\\(OAc)\end{matrix}\right. \\ | \\ CO(OEt). \end{matrix}$$

$$\text{rtaric ether } C_{20}H_{30}O_{11} = \begin{matrix} CO(OEt) \\ | \\ C_2H_2 \\ | \\ CO(OEt) \end{matrix}\left\{\begin{matrix}O-Sü-O\\(OH)(HO)\end{matrix}\right\}\begin{matrix} CO(OEt) \\ | \\ C_2H_2 \\ | \\ CO(OEt). \end{matrix}$$

VIII.

$$\text{of methylsalicyl } C_8H_8O_2 = \begin{matrix} COH \\ | \\ C_6H_4(O\,Me) \end{matrix}$$

$$\text{of ethylsalicyl } C_9H_{10}O_2 = \begin{matrix} COH \\ | \\ C_6H_4\,(OEt) \end{matrix}$$

IX.

$$\text{of salicyl and acetic anhydride } C_{11}H_{12}O_5 = \begin{matrix} CH\left\{\begin{matrix}(OAc)\\(OAc)\end{matrix}\right. \\ | \\ C_6H_4(OH). \end{matrix}$$

X.

n $C_9H_6O_2$, artificially prepared from hydride of sodium-salicyl, anhydride. It is probably ortho-oxyphenyl acrylic anhydride
$\left.I_2\right\}CO.$

c coumarin, ortho-oxyphenylcrotonic anhydride
$C_6H_4\left\{\begin{matrix}O\\C_3H_4\end{matrix}\right\}CO,$
s above, but employing propionic anhydride.

coumarin, ortho-oxyphenylangelic anhydride
$C_6H_4\left\{\begin{matrix}O\\C_4H_6\end{matrix}\right\}CO,$
s above, but employing butyric anhydride.

coumarin, ortho-oxyphenylpyroterebic anhydride (?)
$C_6H_4\left\{\begin{matrix}O\\C_5H_8\end{matrix}\right\}CO,$
s above, but employing valeric anhydride.

XI.

α Bromocoumarin $C_9H_5BrO_2 = C_6H_4\left\{\begin{matrix} O \\ C_2HBr \end{matrix}\right\}CO.$

β Bromocoumarin $C_9H_5BrO_2 = C_6H_3Br\left\{\begin{matrix} O \\ C_2H_2 \end{matrix}\right\}CO.$

α Dibromocoumarin $C_9H_4Br_2O_2 = C_6H_3Br\left\{\begin{matrix} O \\ C_2HBr \end{matrix}\right\}CO.$

β Dibromocoumarin $C_9H_4Br_2O_2 = C_6H_2Br_2\left\{\begin{matrix} O \\ C_2H_2 \end{matrix}\right\}CO.$

α Chlorocoumarin $C_9H_5ClO_2 = C_6 \left\{\begin{matrix} O \\ C_2HCl \end{matrix}\right\}CO.$

Tetrachlorocoumarin $C_9H_2Cl_4O_2$.

Coumarilic acid $C_9H_6O_3 = C_6H_4\left\{\begin{matrix} O \\ C_2H(OH) \end{matrix}\right\}CO.$

Potassic coumarilate $C_9H_5KO_3 = C_6H_4\left\{\begin{matrix} O \\ C_2H(OK) \end{matrix}\right\}CO.$

Sulphocoumarilic acid $C_9H_6O_3SO_3 2H_2O$.

Baric sulphocoumarilic $C_{18}H_{10}BaO_4S_2O_6 = 5H_2O$.

Baric disulphocoumarilic acid $C_9H_4BaO_2S_2O_6H_2O$.

Bromopropionic coumarin $C_{10}H_7BrO_2$.

XII.

Chlorinated chloride of methyl, dichloride of methylene CH_2Cl_2.

XIII.

Anthracene $C_{14}H_{10}$.

Dichloranthracene $C_{14}H_8Cl_2$.

Dibromanthracene $C_{14}H_8Br_2$.

Dichloranthracene combined with picric acid $C_{14}H_8Cl_2C_6H_3(NO_2)_3O$.

Sodic disulphodichloranthracenate $C_{14}H_6Cl_2\left\{\begin{matrix} NaSO_3 \\ NaSO_3 \end{matrix}\right.$.

Baric disulphodichloranthracenate $C_{14}H_6Cl_2Ba2SO_3$.

Strontic disulphodichloranthracenate $C_{14}H_6Cl_2Sr2SO_3$.

Baric disulphodibromanthracenate $C_{14}H_6Br_2Ba2SO_3$.

Anthraquinone $C_{14}H_8O_2$.

Baric disulphanthraquinonate $C_{14}H_6O_2Ba2SO_3$.

XIV.

Artificial alizarin $C_{14}H_8O_4 = C_6H_4\left\{\begin{matrix} CO \\ CO \end{matrix}\right\}C_6H_2(OH)_2$.

Acetyl alizarin $= C_{16}H_{10}O_5 = C_6H_4\left\{\begin{matrix} CO \\ CO \end{matrix}\right\}C_6H_2\left\{\begin{matrix} (OH) \\ (OAc) \end{matrix}\right.$.

Diacetyl alizarin $= C_{18}H_{12}O_6 = C_6H_4\left\{\begin{matrix} CO \\ CO \end{matrix}\right\}C_6H_2(OAc)_2$.

XV.

Bromalizarin $C_{14}H_7BrO_4 = C_6H_4\left\{\begin{matrix} CO \\ CO \end{matrix}\right\}C_6HBr(OH)_2$.

Diacetylbromalizarin $C_{18}H_{11}BrO_6 = C_6H_4\left\{\begin{matrix} CO \\ CO \end{matrix}\right\}C_6HBr(OAc_2)$

XVI.

itroalizarin $C_{14}H_7(NO_2)O_4 = C_6H_4\left\{\begin{matrix}CO\\CO\end{matrix}\right\}C_6H(NO_2)(OH)_2$.

midoalizarin $C_{14}H_7(NH_2)O_4 = C_6H_4\left\{\begin{matrix}CO\\CO\end{matrix}\right\}C_6H(NH_2)(OH)_2$.

XVII.

nthrapurpurin $C_{14}H_8O_5 = C_6H_3(OH)\left\{\begin{matrix}CO\\CO\end{matrix}\right\}C_6H_2(OH)_2$.

riacetylanthrapurpurin $C_{20}H_{14}O_8 = C_6H_3(OAc)\left\{\begin{matrix}CO\\CO\end{matrix}\right\}C_6H_2(OAc)_2$.

XVIII.

nthraflavic acid $= C_{14}H_8O_4 = C_6H_3(OH)\left\{\begin{matrix}CO\\CO\end{matrix}\right\}C_6H_3(OH)$.

aric anthraflavate $2C_{14}H_6BaO_4, 8H_2O$.

iacetoanthraflavic acid $= C_{18}H_{12}O_6 = C_6H_3(OAc)\left\{\begin{matrix}CO\\CO\end{matrix}\right\}C_6H_3(OAc)$.

XIX.

ew isomer of alizarin yielding anthrapurpurin on fusion with potassic rate $C_{14}H_8O_4$.

XX.

rystallized glyoxylic acid obtained from dibromacetic acid $C_2H_4O_4 =$
(OH)

$\left\{\begin{matrix}OH\\OH\end{matrix}\right.$

lcic glyoxylate $C_4H_6Ca''O_4$.

36a. Chemical Preparations (61) from the works of lhardt, Latschinow, Wolkow, Maïkupar. Produced in the atory of the Agricultural Institute of St. Petersburg.

Chemical Society of Russia, University of St. Petersburg.

6b. Preparations from Acids (8), by Lokolow and inow (from acids).

Chemical Laboratory of the Agricultural Institute of St. Petersburg.

c. Chemical Preparations (80) from the works of w, Menschutkin, Gustavson, Lwow, Wazne, Wyschne-, Jernialajew, Popow, Prianichnikow, Nakapetian, Ta-

Chemical Laboratory, University of St. Petersburg.

d. Original Chemical Preparations (38), by Von C. tained in his researches on Platina.

hemical Laboratory, Imperial Berg-Institute, St. Petersburg.

Chemical Preparations (3), by L. Chishkow, obis researches on **Fulminating Mercury.**

Chemical Laboratory, Michailow Artillery Academy.

2536f. Chemical Preparations (41), by Fritzshe and Zinin.

Chemical Laboratory, Imperial Academy of Sciences, St. Petersburg.

2536g. Chemical Preparations (124), by Bilstein, Kuhlberg, Kurbaton, Hemilian, Rudnen, and 81 preparations by Wrohlesky.

Chemical Laboratory, Technological Institute, St. Petersburg.

2537. Pneumati ... ed in his experiments by Dr. Joseph Black, Professor ... ry in the University of Edinburgh from 1766 to 17 ... ck was the discoverer of fixed air (carbonic acid), and ... f the theory of latent heat.

... Museum of Science and Art.

2538. Glass Chemic... ... **ls** (retort, bottle, and flask or receiver) used in the chem ... oratory of the University of Edinburgh during the latt ... of last century. Exhibited to show the contrast b ... and vessels used for similar purposes at the prese ...

Edinb... gh Museum of Science and Art.

APPARATUS EMPLOYED BY THE LATE THOMAS GRAHAM, F.R.S., MASTER OF THE MINT, IN HIS PRINCIPAL RESEARCHES BETWEEN THE YEARS 1834 AND 1866. The series is interesting as showing the simplicity of the appliances with which Graham worked, and by the aid of which he discovered facts and established laws which have since proved to be of so much importance.

W. Chandler Roberts, F.R.S.

2539. Tubes with discs of graphite and hydrophane employed by Graham in experiments on "diffusion" of gases.

These experiments were commenced in 1834, when the discs were formed of plaster of Paris. The instrument consists of a graduated glass tube, open at one end and closed at the other by the porous substance. When such a diffusion tube is filled with a gas over mercury an interchange of the gas and the air takes place through the porous septum. By experiments such as these Graham determined the diffusion rates of different gases, and developed the law that their diffusibilities vary in the inverse ratio of the square roots of their densities

2540. The Apparatus employed for ascertaining the diffusion rates of liquids (Bakerian Lecture, 1849).

The saline solution to be diffused was placed in the inner vessel, which communicated freely with distilled water in the outer vessel. It was shown by this means that, when two liquids of different density and capable of mixing are placed in contact, diffusion takes place between them, much in the same manner as between gases, except that the rate of diffusion, which varies with the nature of the liquids, the temperature, and the degree of concentration is slower. The phenomena are governed by several well ascertained laws, for a brief account of which *see* Watts's Dictionary of Chemistry, Vol III., p 705.

2541. Osmometers, or apparatus employed in Graham's researches on "Osmotic Force."

The diffusion of a salt appears to take place without difficulty or loss through the substance of a thin septum, although the mechanical flow of a liquid may be nearly stopped by such an obstacle. This diffusion is termed "Osmose." The experiments of Graham led to the conclusion that osmose depends essentially on the chemical action of the liquid on the septum. The base of the bell glass is covered either with thin unglazed earthenware or animal membrane, and is of such a size that the area of the opening is 100 times that of the tube, in order to facilitate the observations.

2542. Apparatus employed in experiments on liquid diffusion applied to analysis and on dialysis.

It consists simply of a gutta-percha hoop, about 9 inches in diameter, on which is stretched a sheet of parchment paper. The solution to be dialysed is placed in the hoop, and the whole floated in a considerable volume of water. Animal membrane, or a mere film of a colloidal septum, permits crystalloids to diffuse freely through it, but is entirely impervious to any colloids, for example gelatine, which may be in solution. The septum does not act in any way as a filter, but permits only the permeation of molecules and not masses. This mode of diffusion Graham termed Dialysis. By its aid he obtained hydrated silicic acid, oxides of iron and alumina, &c., all soluble in water, and he succeeded in separating crystalloid poisons from organic matter in toxicological investigations.

2543. Apparatus by which Graham studied capillary liquid transpiration in relation to chemical composition.

The globe was filled with the liquid under examination, and the force employed to impel it through the capillary was the weight of 1 atmosphere, and was obtained from compressed air contained in the large reservoir, which was provided with a mercurial gauge.

2544. Tube Atmolyser, or instrument for the separation of gases by diffusion.

As gases differ in the rate at which they transpire through a porous septum, it follows that, when a mixture of gases is in contact with a septum, while the other side is vacuous, the per-centage composition will be changed. The atmolyser consists of a bundle of tobacco-pipe stems, enclosed in a glass tube, which can be rendered vacuous. The mixed gases are passed through the tube. For example, an explosive mixture of 66 per cent. by volume of hydrogen and 33 per cent. of oxygen was passed through the tube. The resulting mixture contained only 9·3 per cent. of hydrogen, and a taper burned in it without explosion.

2545. Barometrical Diffusiometer, used for the investigation of the molecular mobility of gases.

The gas under examination was allowed to enter either a perfect or partial vacuum through a thin porous septum. The results proved that the diffusion rates of the gases closely correspond with the law which has already been given, and quite excluded the idea of capillary transpiration, which would give for the same gases an entirely different result.

2546. Apparatus employed in experiments on **Absorption** and dialytic separation of gases by colloid septa.

(1.) Waterproof silk bag for the dialysis of air. When the bag is exhausted by means of a Sprengel pump the air which penetrates the

walls of the bag is found to contain 42 per cent. of oxygen the per-centage of oxygen present is doubled.

(2.) The penetration of metals by gases was studied by the aid of tubes, of which the palladium tube shown is one. It was in a tube of glass or porcelain, and rendered vacuous by the Sprengel exhauster; a stream of gas was then passed thro annular space between the tubes. In the cold no hydrogen through palladium, but at a red heat the gas passes at a nearly 4000 cubic cent per square metre of surface in a min

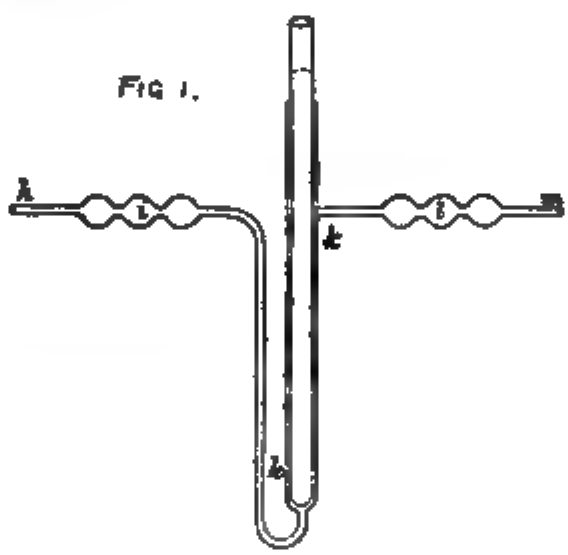
2547. Apparatus for Gas Experiment, as used fo determination of the Composition of Ozone.

Sir B. C.

This apparatus will be described in the form in which it was empl the determination of the composition of ozone, the object being to de the changes which electrized oxygen underwent when subjected to th of heat or of chemical reagents.

A current of pure and dry oxygen was passed through an inducti fundamentally of the kind devised by Siemens, but the inner tube wa filled with water, in which was placed one of the terminal wires of korff's coil, the tube itself being immersed in a vessel of water co with the other terminal wire of the coil. The tube is delineated in The gas enters the apparatus at h, and, passing over anhydrous-pho acid contained in the three bulbs i, traverses the narrow space k betw two tubes, and is there submitted to the electric action, after wh electrized gas is again passed over anhydrous phosphoric acid conta the three bulbs l, and is delivered at m.

FIG. 1.



The electrized gas is collected and preserved for the purpose of exper in a gas-holder, delineated in Fig. 2. On this side of the inductio connexions of caoutchouc can no longer be employed, this substance instantaneously corroded by even the minutest trace of ozone, and the f between the gas-holder and the induction tube is effected by means of may be termed a paraffin joint. Over the tubes to be connected, wh placed close together, is slipped a piece of glass tube into which they fit, and from which they are separated by a capillary space; a fragm pure paraffine is placed at the external junction of the tubes. The u the tubes is effected by gently melting the paraffin; the liquid par extremely limpid, and runs into and fills up the narrow space betwe

When the paraffin is solidified, the tubes are united by a joint, perfectly air-tight, which will resist very considerable pressure, and quite unaffected by the passage of the ozone. This simple joint is al feature of this arrangement, and will doubtless be of great many forms of gas apparatus.

s-holder consists of a glass bell p, contained in a glass cylinder q, t is suspended, being supported by a knob of glass passing through d to the top of the jar. This cap is made in two pieces, which are tly united so as to be readily placed in a proper position as a the glass bell.

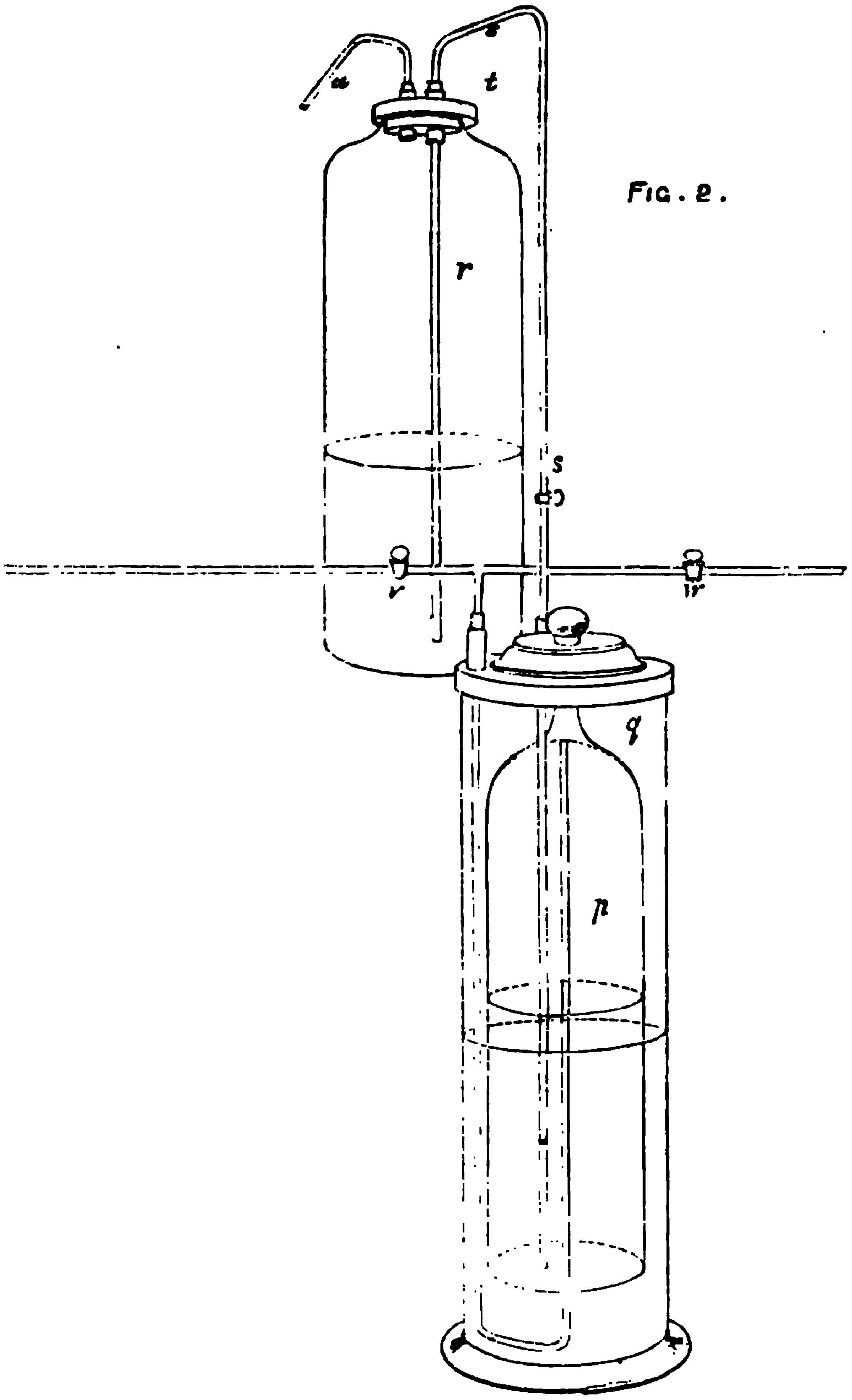


FIG. 2.

[illegible] is placed a glass jar *r*, containing pure [illegible] [illegible] sulphuric acid. This jar is connected by a syphon tube *s* [illegible] [illegible] with the lower cylinder *q*. This upper [illegible] [illegible] the reservoir, is closed by a cap *t*, through which [illegible] [illegible] passes, and in which is also fitted a second glass tube *u*. [illegible] [illegible] is delivered at *n*, whence it passes into the [illegible] [illegible] which is best understood from the [illegible] [illegible] of the gas is regulated by means of an air pump, [illegible] glass tube [illegible] by a tube of caoutchouc.

The volume of gas submitted to experiment was measured [illegible] [illegible] of which a drawing is given in Fig. 3. The capacity of [illegible] [illegible] between the two marks *b* and *c* was [illegible] [illegible] with mercury. It was then welded to a glass tube of the [illegible] [illegible] figure. [illegible] of sulphuric acid with a syphon tube [illegible] [illegible] containing water, in which the pipette *a* is [illegible] [illegible] thermometer is placed. The gas pipette is connected [illegible] holder by a paraffin joint at *f*. The arrangements for working [illegible] are similar to those in the case of the gas-holder.

In order to [illegible] the changes in bulk which the electrized

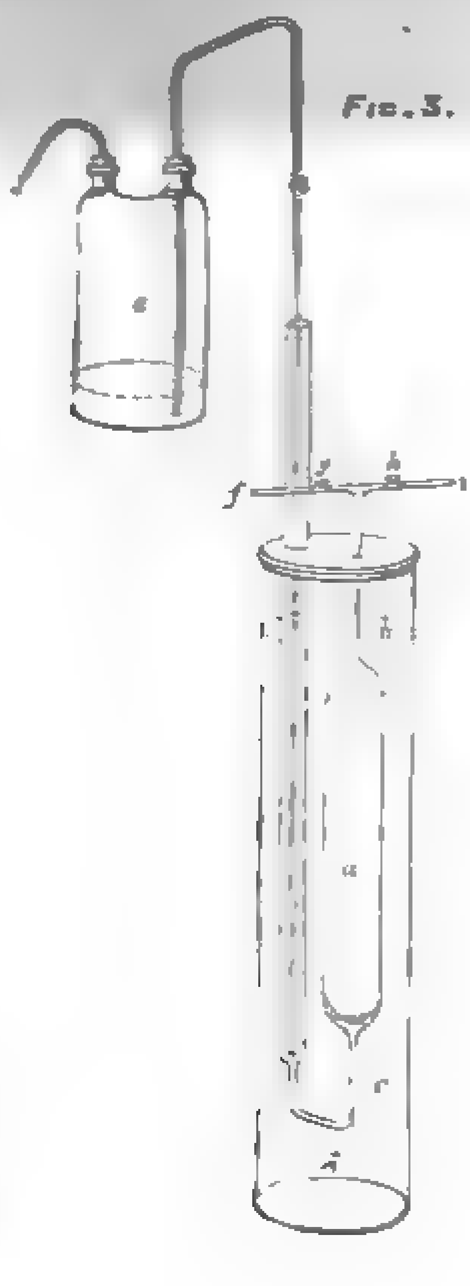


Fig. 3.

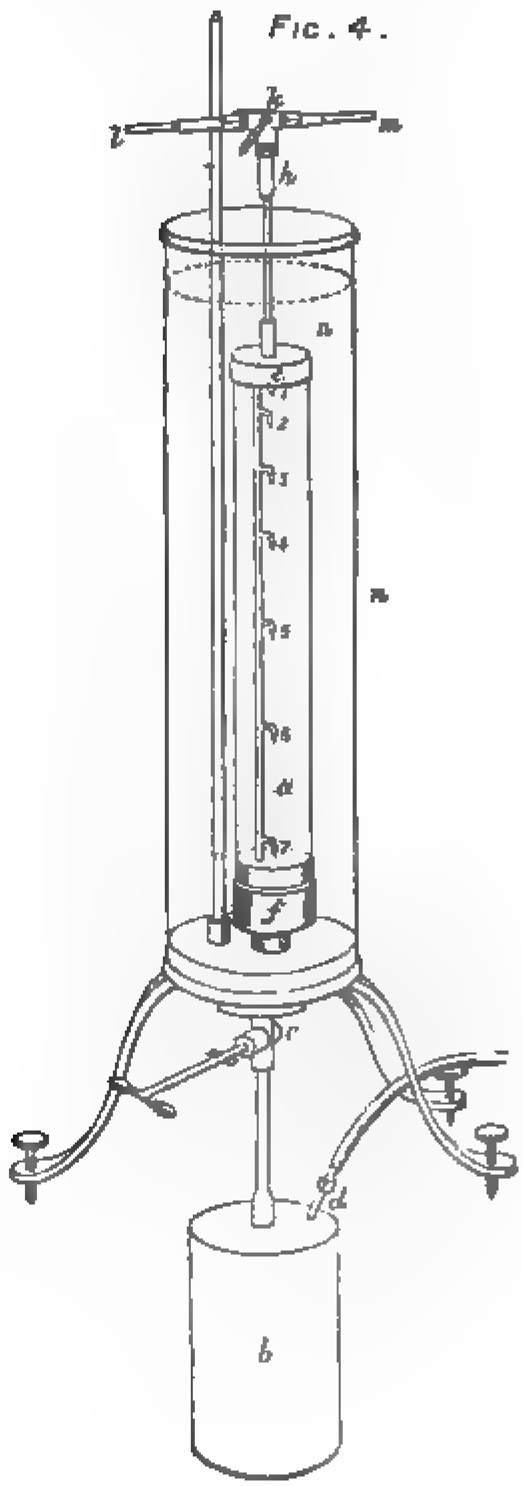
[illegible] ly heated, [illegible]

ous experiments hereafter described, the measuring apparatus of which a drawing is given, Fig. 4. In this apparatus, m the aspirator, the volumes of gas at 0° C. and 760 millims. tained by determining the pressure which it is necessary to s in order to cause it to occupy a known space at a known his is the principle of Regnault's apparatus for gas analysis, kland's apparatus.

as placed on a table, being separated from the aspirator by out 8 or 10 inches. In this interval the experiment to which s was submitted was made.

consists of a cylinder of strong glass a, connected by an iron a reservoir, b, containing an amount of mercury rather more

FIG. 4.



to fill the cylinder a. In the iron tube connecting the cylinder
voir is intercalated a stopcock c, by which the connexion
cylinder and reservoir may at pleasure be made or cut off. In
reservoir b a small iron tube d is inserted, connected by a tube of
caoutchouc with a forcing pump firmly fixed to the table on which the apparatus is placed. By means of this forcing pump the air contained in the upper part of the reservoir may be compressed, and any required pressure put upon the mercury contained in it. The cylinder a is cemented by means of a resinous cement into two steel caps, e and f; the lower cap f is screwed
firmly upon the support of … a, which is made of iron. The
cylinder is connected … cut in the lower part of the steel
cap f and continued … ure, with a glass tube g, which is
about half an inch in … ated in millimetres. This tube I
shall speak of as the pressure … cylinder a and the pressure tube g
are thus in permanent connexi… stitute one vessel, which is broken
into parts solely for facility … on. This apparatus is supported
upon three screws, as shown … by the adjustment of which the
pressure tube g is placed in a … ar position before the commence-
ment of the experiment. The … cock h is a three-way stopcock, in
which the channels are so cut … munication may be made between
the tube l and the cylinder a, … the tube m and the cylinder a, or
between the tubes l and m (al… ommunications being shut off) at
pleasure; or the communication … tirely closed.

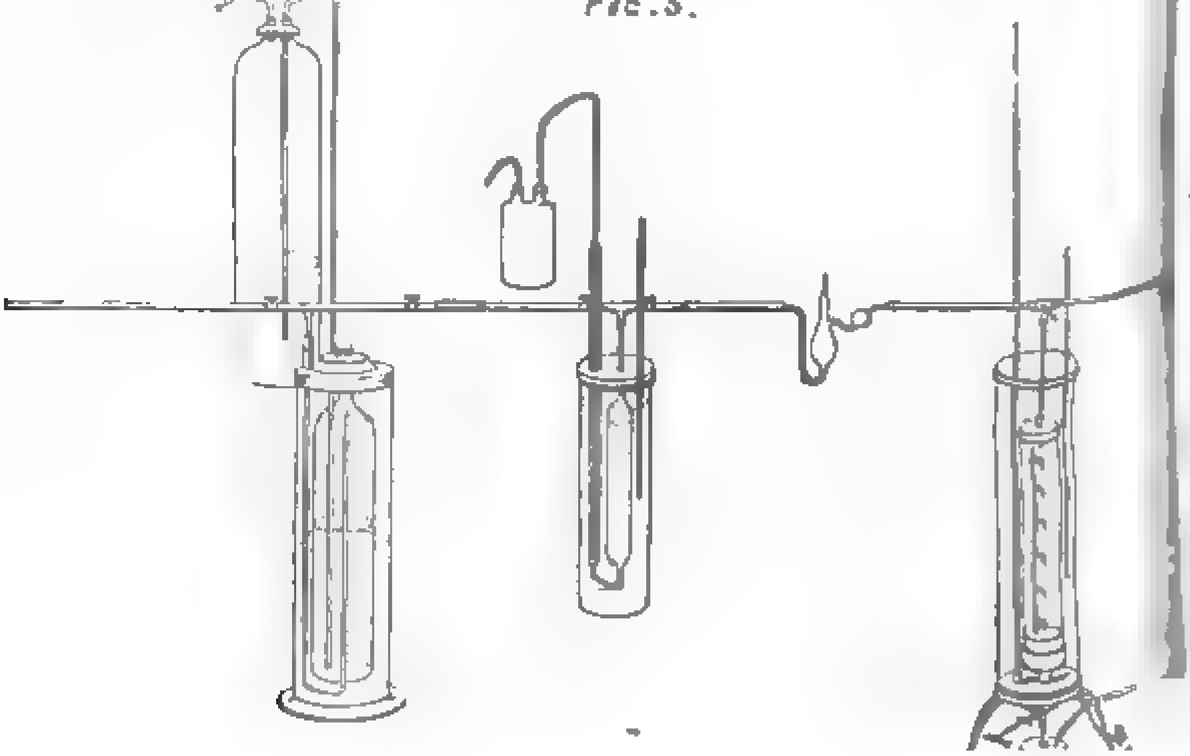
In the cylinder a is placed a … of glass rod, to which seven points
are attached, also of glass, as … the figure. The capacity of the cylinder a between each point is ascertained by calibration with mercury.

The cylinder and pressure tube are enclosed in a second glass cylinder filled with water, in which a thermometer is placed.

For further detail as to the construction, calibration, and mode of operating with the apparatus, see Phil. Trans., 1872, p. 3.

In Fig. 5 a drawing is given of the whole apparatus as arranged for experiment.

FIG. 5.



1431. Collection of Vanadium Compounds.

Professor H. E. Roscoe, F.R.S.

1. Vanadium ore, containing 2 per cent. vanadium.
2. Roasted vanadium ore.
3. Ammonium meta-vanadate (3rd crystallization).
4. Pure vanadium pentoxide, V_2O_5.
5. Vanadium tetroxide, V_2O_4.
6. Vanadium trioxide, V_2O_3.
7. Vanadium pentoxide, containing phosphorus.
8. Vanadium mononitride, VN.
9. Vanadium platinum alloy.
10. Vanadium silicon alloy.
11. Ammonium meta-vanadate (pure), NH_4VO_3.
12. Lead meta-vanadate, $Pb2VO_3$.
13. Di-vanadyl monochloride, V_2O_2Cl.
14. Vanadium tetrachloride (VCl_4) decomposed into vanadium trichloride (VCl_3) and Chlorine (Cl).
15. Vanadous sulphate. }
16. Copper sulphate. }
17. Potassium anhydro-chromate. }
18. Potassium anhydro-vanadate. }
19. Sodium ortho-vanadate, $Na_3VO_4+16H_2O$.
20. Sodium ortho-vanadate (fused mass).
21. Artificial vanadinite 3 $(Pb_3V_2O_8)+PbCl_2$.
22. Fused mass of artificial vanadinite.
23. Silver ortho-vanadate, Ag_3VO_4.
24. Sodium pyro-vanadate, $Na_4V_2O_7+18H_2O$.
25. Sodium pyro-vanadate, crystallized from alcohol.
26. Barium pyro-vanadate, $Ba_2V_2O_7$.
27. Basic pyro-vanadate of lead $2(Pb_2V_2O_7)+PbO$.
28. Silver pyro-vanadate, $Ag_4V_2O_7$.
29. Meta-vanadic acid, HVO_3.
30. Ammonium meta-vanadate NH_4VO_3 (crystallized).
31. Sodium anhydro-vanadate $2(NaVO_3)+V_2O_5$ (v. Hauer).
32. Calcium di-vanadate, $Ca2VO_3+V_2O_5+18H_2O$ (v. Hauer).
33. Vanadium metal, $V=51\cdot3$.
34. Pure vanadium pentoxide. From $VOCl_3$.
35. Vanadium nitride, VN. From metal and VCl_4.
36. Vanadium nitride, VN. From pure VCl_2.
37. Vanadium nitride, VN. From V_2O_3.
38. Vanadium nitride, VN. From NH_4VO_3.
39. Vanadyl dichloride, $VOCl_2$.
40. Vanadium sesquioxide, undergoing oxidation.
41. Ammonium magnesium phosphate. From Berzelius's vanadium (1831).
42. Thallium tetra-vanadate, $Tl_{12}V_4O_{16}$ (or $4Tl_3VO_4$).

43. Thallium hexa-vanadate, $Tl_{12}V_6O_{21}$.
44. Thallium octa-vanadate, $Tl_{12}V_8O_{26}$.
45. Silver octa-vanadate, $Ag_{12}V_8O_{26}$.
46. Sodium octa-vanadate, $Na_{12}V_8O_{26}$.
47. Thallium deca-vanadate, $Tl_{12}V_{10}O_{31}$.
48. Thallium dodeca-vanadate, $Tl_{12}V_{12}O_{36}$.
49. Thallium tetra-kai-deca-vanadate, $Tl_{12}V_{14}O_{41}$.
50. Vanadium metal, $V=51\cdot3$.
51. Vanadium oxidibromide, $VOBr_2$.
52. VCl_4 decomposed into VCl_3+Cl.
53. Vanadium oxitrichloride, $VOCl_3$.
54. VCl_4 undergoing decomposition.
55. Vanadium dichloride, VCl_2.
56. Vanadium trichloride, VCl_3.
57. Vanadium pentoxide, V_2O_5.

58. V_2O_5.		Solutions of the oxides in sulphuric acid.
59. V_2O_4 by reduction with	SO_2.	
60. V_2O_3 „ „	Mg.	
61. V_2O_2 „ „	Na or Zn.	

62. $VOCl_3$	Obtained by throwing these compounds into water.
63. VCl_4	
64. VCl_3	
65. VCl_2	

2431a. 1. **Calorimeter,** by M. Berthelot, for thermo-chemical investigations, with electric mover of the agitator.

2. Air Thermometer, by M. Berthelot, glass, showing the temperature up to 550 degrees.

3. Air Thermometer, by M. Berthelot, silver, showing the temperature up to 900 degrees.

4. Apparatus for proving the disengagement of heat in the reaction of two gases.

5. Apparatus, by M. Berthelot, for the endothermic decomposition of formic acid by heat.

6. Two sealed globes, for the synthesis of formic acid by direct union of the oxide of carbon with potash, and sample of formate of lead, obtained by synthesis.

7. Apparatus, by M. Berthelot, for the synthesis of acetylene.

8. Bell glass, curved, in which was effected the synthesis of benzine, by the condensing of acetylene, by M. Berthelot; also another bell glass, empty.

9. Alcohol, obtained synthetically, by the union of olefiant gas with water.

10. Sealed tubes, containing organic matter, hydrogenized by iodhydric acid. *Laboratory of the College of France.*

2432. Series of Cryohydrates. *Frederick Guthrie, F.R.S.*

These are solutions of various salts in water, of such strengths that, when reduced below 0°C to the temperature marked on each flask, the salt and

ie water solidify together at that temperature. The same bodies in all ses result from the mixture of the respective salt with ice as a freezing ixture.

2433. Graphic Diagram, showing (1) the solubility of ice i the cryohydrates of various salts, (2) the composition of the yohydrates and their melting points, (3) the solubility of the hydrous salts in the cryohydrates and in water, (4) the temperure which the salt produces when used in a freezing mixture ith ice or as an ice cryogen. *Frederick Guthrie, F.R.S.*

2434. Metallic-Chrome. A specimen prepared by Nobili, id presented by him to the Royal Institution. *Mrs. Faraday.*

2435. Nitroxide of Amylen. *Frederick Guthrie, F.R.S.*

Discovered by the exhibitor. Of historical interest as being the first stance in which peroxide of nitrogen NO^4 was shown to behave as a logen in uniting directly with an olefine to form a body homologous with Dutch liquid." The composition of the body is $C_5H_{10}2NO_2$.

2436. Sulphide of Œnanthyl. *Frederick Guthrie, F.R.S.*

Discovered by the exhibitor, and of historical interest as being the first stance in which a term of a higher alcohol series was made from terms of wer alcohols. Formed by the action of zinc ethyl on sulpho-chloride of nylen.

2437. Nitrite of Amyl. *Frederick Guthrie, F.R.S.*

Discovered by M. Balard. Its therapeutic action discovered, and its troduction into the pharmacopœa recommended, by the exhibitor. Now ming into use in tetanic and other nervous affections.

2438. Collection of Preparations relating to chemical istory of podocarpic acid (Annalen der Chemie und Pharmacie, ol. 170, p. 213). *Prof. A. C. Oudemans, Delft.*

2439. Hydrocarbons and Derivatives from Pennsylvania etroleum. 23 specimens. *C. Schorlemmer, F.R.S.*

Group I.—Normal Paraffins.
Pentane. Pentene. Pentylchlorides.
Hexane. Hexene. Hexylchlorides. Hexylacetates. Hexylalcohols.
Heptane. Heptene. Heptylchlorides. Heptylalcohols. Octane.
Group II.—Isoparaffins.
Isopentane. Isohexane. Isoheptane.
Group III.—Aromatic Nitro-compounds.
Di-nitro-benzene. Di-nitrotoluene,
Nitro-compounds from fraction
boil 110—120
120—130
130—140 solid and liquid.
140—150.

2440. Ethyl-Compounds, derived from dimethyl, which was obtained by the electrolysis of potassium acetate. Four specimens. *W. H. Darling.*

Ethyl-chloride. Ethyl-alcohol. Dichlorethane. Sodium Acetate.

2484. Aurin and Derivatives. 14 specimens.
C. Schorlemmer, F.R.S., and R. S. Dale, B.A.

Two specimens of commercial aurin.
Three specimens of pure aurin crystallised from alcohol.
Four specimens of pure aurin crystallised from acetic acid.
One specimen of compound of aurin and sulphur dioxide.
One specimen of aurin-potassium sulphite.
One specimen of leucaurin.
One specimen of triacetyl-leucaurin.
One specimen of red aurin or peonin.

2485. Organic Compounds relating to the dry distillation of the "Galipot" resin, and to the constitution of pimaric acid (personal researches of the author). *Gustave Bruylants, Louvain.*

2486. Organic Compounds relating specially, 1° to the question of isomerism in glycerin derivatives; 2° to indicate the trialcoholic character of glycerin; 3° to show the reciprocal relations of allium compounds with glycerin compounds; 4° to propargylic compounds, and to the relations of allium compounds with propargylic compounds; 5° to binary compounds of allium; 6° to the binary propargylic compounds, and their relations with binary compounds of allium; 7° to the structure of the addition-products of hypochlorous acid.

Certain groups of these products are intended show: 8° the alcoholic character of alcohol acids, of basic ethers, and polyatomic alcohols, &c.; 9° the stability of the groupings Oxy-alcoholic Cn, H O in presence of PCl_5, PBr_5, &c., in opposition to the energetic reaction to which the corresponding hydro-oxygen compounds (O H) are subjected on the part of these re-agents, &c., and as a consequence the synthesis of oxalic acid, &c.

Louis Henry, Louvain.

2487. Mono-benzyl Urea, obtained by the action of ammonia on isocyanate of benzyl. Crystallized from water. (*See* Journal of Chemical Society, June 1872.)

Formula $CO\begin{cases} NHC_7H_7 \\ NH_2 \end{cases}$

Dr. E. A. Letts and Mr. J. Fulton.

2488. Isocyanurate of Benzyl, obtained by the action of chloride of benzyl on cyanate of silver. Crystallized from alcohol. (*See* Journal of Chemical Society, June 1872.)

Formula $(C_7H_7—NCO)_3$

Dr. E. A. Letts and Mr. J. Fulton.

2489. Benzyl-phenyl Urea, obtained by the action of aniline on isocyanate of benzyl. The compound is unstable. (*See* Journal of Chemical Society, June 1872.)

Formula $CO\begin{cases} NHC_7H_7 \\ NHC_6H_5 \end{cases}$

Dr. E. A. Letts and Mr. J. Fulton.

90. Dibenzyl Urea, obtained by the action of water on
ınate of benzyl. The specimen was crystallized from alcohol.
Journal of Chemical Society, June 1872.)

$$\textit{Formula}\quad CO\begin{cases} NHC_7H_7 \\ NHC_7H_7 \end{cases}$$

Dr. E. A. Letts and Mr. J. Fulton.

91. Isocyanate of Benzyl mixed with chloride of benzyl,
ıed by heating chloride of benzyl with cyanate of silver. The
ınate of benzyl cannot be obtained in the pure condition, as it
y becomes polymerized into isocyanurate of benzyl. (*See*
ıal of Chemical Society, June 1872.)

Formula of the isocyanate $C_7H_7-N{=}C{=}O$

Dr. E. A. Letts and Mr. J. Fulton.

92. Hydrobromate of Dimethyl Thetine, obtained by
›tion of sulphide of methyl on bromacetic acid. The specimen
rystallized from alcohol. (*See* Proceedings of Royal Society
inburgh, vol. viii., Nos. 87 and 89.)

$$\textit{Formula}\quad \begin{array}{c} CH_3 \\ | \\ Br—S—CH_2—COOH \\ | \\ CH_3 \end{array}$$

Professor A. Crum Brown and Dr. E. A. Letts.

93. Hydrochlorate of Dimethyl Thetine, obtained by
ion of chloride of barium on sulphate of dimethyl thetine.
ecimen was separated from an aqueous solution by a mix-
alcohol and ether.

$$\textit{Formula}\quad \begin{array}{c} CH_3 \\ | \\ Cl-S-CH_2-COOH \\ | \\ CH_3 \end{array}$$

›roceedings of the Royal Society of Edinburgh, vol. viii.,
ınd 89.)

Professor A. Crum Brown and Dr. E. A. Letts.

Sulphate of Dimethyl Thetine, obtained by the
ulphate of silver on hydrobromate of dimethyl thetine.
ıen was crystallized from water.

$$\begin{array}{ccccccccc} & & CH_3 & & CH_3 & & \\ & & | & & | & & \\ HOOC—CH_2 & — & S & —SO_4— & S & — & CH_2—COOH \\ & & | & & | & & \\ & & CH_3 & & CH_3 & & \end{array}$$

(*See* Proceedings of the Royal Society of Edinburgh, vol. viii., Nos. 87 and 89.)

Professor A. Crum Brown and Dr. E. A. Letts.

2495. Poly-iodide of Dimethyl Thetine, obtained by the slow action of hydriodic acid on the base dimethyl thetine.

Not yet analysed.

(*See* Proceedings of the Royal Society of Edinburgh, vol. viii., Nos. 87 and 89.)

Professor A. Crum Brown and Dr. E. A. Letts.

2496. Nitrate of Dimethyl Thetine, obtained by the action of nitrate of silver on hydrobromate of dimethyl thetine. The specimen was crystallized from alcohol.

Formula $$NO_3—\overset{\displaystyle CH_3}{\underset{\displaystyle CH_3}{\overset{|}{\underset{|}{S}}}}—CH_2—COOH$$

(*See* Proceedings of the Royal Society of Edinburgh, vol. viii., Nos. 87 and 89.)

Professor A. Crum Brown and Dr. E. A. Letts.

2497. Dimethyl Thetine, obtained by the action of water and oxide of silver on the hydrobromate of dimethyl thetine, or by the action of carbonate of barium on the sulphate. The base loses a molecule of water at 100° C.

Formula $$HO—\overset{\displaystyle CH_3}{\underset{\displaystyle CH_3}{\overset{|}{\underset{|}{S}}}}—CH_2—COOH$$

(*See* Proceedings of the Royal Society of Edinburgh, vol. viii., Nos. 87 and 89.)

Professor A. Crum Brown and Dr. E. A. Letts.

2498. Lead Salt of Hydrobromate of Dimethyl Thetine, obtained by the action of the latter on carbonate of lead. The specimen was crystallized from hot water.

Formula $$Br—\overset{\displaystyle CH_3}{\underset{\displaystyle CH_3}{\overset{|}{\underset{|}{S}}}}—CH_2—COOPbBr,\ 2PbBr_2$$

(*See* Proceedings of the Royal Society of Edinburgh, vol. viii., Nos. 87 and 89.)

Professor A. Crum Brown and Dr. E. A. Letts.

2499. Glass Digester in which to heat substances under pressure.

The apparatus consists of a well-annealed glass cylinder, closed at one end and drawn out at the other to a tube. Its capacity is about 600 cubic centimetres; the thickness of its walls about $\frac{1}{2}$ an inch throughout. The tube forming the neck is about $\frac{1}{6}$ of an inch in bore, and is closed by an accurately ground glass plate. The glass cylinder is mounted in a framework of brass, provided with a screw, which when turned presses the glass plate tightly against the tube, and thus hermetically closes the digester. The apparatus has been employed in the preparation of bromacetic acid, and large quantities of that substance have been prepared by its aid. The digester is intended as a substitute for sealed tubes, and has the great advantage over these that large quantities of substance can be heated at one operation, and that the danger of unsealing is avoided.

The apparatus is heated in an oil bath. *Dr. E. A. Letts.*

2500. Methyl-Sulphate of Calcium.
Dr. E. A. Letts and Mr. C. Abraham.

2501. Methyl-sulphate of Zinc.
Dr. E. A. Letts and Mr. C. Abraham.

2502. Methyl-sulphate of Ammonium.
Dr. E. A. Letts and Mr. C. Abraham.

2503. Specimens of Acetamide, Butyramide, Isobutyramide, and Valeramide; also of Valero-nitrile and Benzo-nitrile. These have been obtained by the action of the corresponding acids on sulphocyanate of potash, according to the equation

$$R-COOH+KCNS=HCNS+R-COOK.$$
$$R-COOH+HCNS=COS+R-CONH_2$$
$$R-COOH+HCNS=H_2S+CO_2+R-CN.$$

(In the case of the fatty acids the amide is the principal product, whilst the nitrile alone appears to be produced from the acid of the aromatic series. The process is easily and rapidly performed, and the yield good in all cases.

(*See* Proceedings of the Royal Society, No. 140, 1873.)
Dr. E. A. Letts and Mr. R. S. Marsden.

2504. Hyposulphite of Copper, Ammonium and Sodium, obtained by mixing a strong solution of hyposulphite of soda with ammonio-sulphate of copper. The salt separates from the solution spontaneously. Its formula is doubtful.
Dr. E. A. Letts and Mr. W. J. Nicol.

2505. Hyposulphite of Magnesium, obtained from hyposulphite of strontium by double decomposition with sulphate of

d subsequent evaporation of the solution on a water

Formula $Mg\ S_2\ O_3,\ 6\ H_2\ O$.

Dr. E. A. Letts and Mr. W. J. Nicol.

2506. [illegible]yposulphite of Strontium, obtained by mixing hot concentr[illegible] solutions of hyposulphite of soda and chloride of strontiu[illegible] The salt separates spontaneously from the solution.

Formula $Sr\ S_2\ O_3,\ 5\ H_2\ O$.

Dr. E. A. Letts and Mr. W. J. Nicol.

2507. [illegible]um, obtained by mixing solutions of [illegible]loride of barium.

[illegible] $O_3,\ H_2\ O$.

[illegible]A. Letts and Mr. W. J. Nicol.

2508. Hyposulphite [illegible]el, obtained from hyposulphite of strontium by double dec[illegible]n with sulphate of nickel, and subsequent evaporation of t[illegible]on in vacuo. The salt readily decomposes.

Fo[illegible] [illegible]$O_3,\ 6\ H_2\ O$.

Dr. [illegible]A. Letts and Mr. W. J. Nicol.

2509. Hyposulphite of Cobalt, obtained from hyposulphite of strontium by double decomposition with sulphate of cobalt, and subsequent evaporation of the solution in vacuo. The salt readily decomposes.

Formula $Co\ S_2\ O_3,\ 6H_2\ O$.

Dr. E. A. Letts and Mr. W. J. Nicol.

2510. Liquid Hydrochlorate of Turpentine, distilled over with water vapour, and dried with chloride of calcium.

Formula $C_{10}\ H_{16}\ HCl$.

Dr. E. A. Letts.

2511. Solid Hydrochlorate of Turpentine, crystallized from alcohol.

Formula $C_{10}\ H_{16}\ HCl$.

Dr. E. A. Letts.

2512. Hydrate of Turpentine (Terpene), crystallized from water. *Dr. E. A. Letts and Mr. James Davidson.*

2513. Hydrate of Hydrocarbon contained in Oil of Lavender (exotic); obtained by allowing a mixture of the oil with dilute alcohol and nitric acid to remain for some weeks at rest. The specimen was crystallized from water. Not yet analysed. *Dr. E. A. Letts and Mr. James Davidson.*

2514. Hydrochlorate of the Hydrocarbon contained in Oil of Lavender (exotic); obtained by saturating oil of

lavender with hydrochloric acid, and distilling with water vapour. No solid modification seems to exist.

Formula $C_{10} H_{16}\, 2\, HCl$.

Dr. E. A. Letts and Mr. James Davidson.

2515. Sulphide of Potassium, obtained by allowing a very concentrated aqueous solution (prepared in the usual way) to remain at rest for some time. Sulphide of potassium is usually stated to be red and uncrystallizable from water.

Dr. E. A. Letts.

2516. Mono-sodium Glycerine, obtained by mixing glycerine with an alcoholic solution of ethylate of sodium. It contains a molecule of alcohol (acting as water of crystallization), which it loses at 100° C.

(*See* Berichte der deutschen chemischen Gesellschaft, 1872.)

Formula $C_3 H_5 (OH)_2 (ONa) + C_2H_6O$.

Dr. E. A. Letts.

2517. Crystallized Pyro-sulphuric Acid, obtained by adding the equivalent quantity of sulphuric anhydride to oil of vitriol.

Formula $H_2 S_2 O_7$

Dr. E. A. Letts.

2518. Pure Oxalate of Methyl, used for the preparation of pure methyl alcohol.

Formula $\begin{array}{l} COOCH_3 \\ | \\ COOCH_3 \end{array}$

Dr. E. A. Letts and R. M. Morrison.

2519. Pure Methyl Alcohol, obtained by the action of aqueous ammonia on the oxalate of methyl, and subsequent dehydration with lime and sodium.

Formula $H—CH_2\, OH$

Dr. E. A. Letts and R. M. Morrison.

II.—MODELS, DIAGRAMS, APPARATUS, &c. EMPLOYED IN TEACHING PURE CHEMISTRY.

2442. Drawings, two, illustrating the making of coal-gas, used for teaching chemistry in the Secondary Schools.

I. Coal-gas factory.

II. Regulator of coal-gas factory.

Dr. D. de Loos, Director of the Secondary Town School, Leyden.

wo Bischof's Evaporating Apparatus to use for)paratus. One graduated nitric acid tube. Enamel
E. Cetti & Co.

ater Quick Filter Pump for use with a fall of 40
E. Cetti & Co.

t of **Russell** and **West's Apparatus** for estimating ine.
E. Cetti & Co.

: **Burettes** and **Scale Pipettes,** with registered) show up the divisions.
E. Cetti & Co.

be with **Beads** to collect the **Ammonia** in **Coal** : the testing stations.
E. Cetti & Co.

ssler's Tubes for **Colour Test.** *E. Cetti & Co.*

vendish's Eudiometer. *E. Cetti & Co.*

's Eudiometer. *E. Cetti & Co.*

tscherlich's Eudiometer. *E. Cetti & Co.*

ed appliance for the analysis of gases with three
M. Orsat, Paris.

ed appliance for the analysis of gases with two
M. Orsat, Paris.

table Appliance for the analysis of gases, giving ' gases, giving the quantity of the hydrogen and its
M. Orsat, Paris.

ad used in chemistry for the fusion of metals by apparatus.

oratory Forge, with double draught, fitted with a fusion of metals.

: the pressure can be increased by reducing the quantity of ng is required, either with gas, or with Mr. Sainte Claire mp, or with Mr. Schlosing's blow pipe.

aratus for **regulating** the **Pressure** of **Gas.**
Prof. A. Crum Brown.

consists of a gasometer, the pressure of the gas in which weight of the inverted vessel and that of the counterpoises. f the arrangement lies in the mode in which the gas is introsometer. The gas is led from the main or meter to a fixed . thence by a short piece of india-rubber tube to a metal e of the counterpoising weights, and from that tube to the n the pressure in the main increases the vessel rises, and the ; the short india-rubber tube is thus bent, and the entrance someter hindered. This short india-rubber tube is thus a , always admitting exactly the same quantity of gas as is ie gasometer.

...LS, DIAGRAMS, APPARATUS, AND PRO... USED IN THE TEACHING OF TECHNICAL CHEMISTRY.

2459. Spence's Process for the Manufacture of Alum. Spe... illustrate the process, consisting of :—

(... of the coal measures before calcination (source of ...lumina).

(1*a*.) Shale after cal...

(2.) Pyrites or bi-... on (source of sulphur for the manufacture of ... acid).

(2*a*.) Nitrate of soda. ... ng the sulphurous acid produced from the ... sulphuric acid.

(2*b*.) Sulphuric acid, ... vity 1·6, as used in the manufacture of alum.

(3.) Gas liquor (source of am... nia).

(3*a*.) Sulphate of a...

(4.) Sulphate of

(5.) Fish crystal ... m (a double salt or compound of sulphate of ammo... nd sulphate of alumina).

(6.) Ammonia alum. Second crystallisation. *Peter Spence.*

2460. Oxalic Acid. Two specimens. One crystallised from a solution containing sulphuric acid, the other from an aqueous solution. *Roberts, Dale, & Co.*

This product is made by the action of caustic potash, or a mixture of caustic potash and caustic soda on woody fibre (sawdust). The result of this action is oxalate of potash. The oxalic acid is isolated by precipitation as oxalate of lime, and the subsequent decomposition of this latter product by sulphuric acid. Specimen No. 2 is crystallised from water. A comparison will show the marked difference in crystalline form due to the presence of sulphuric acid.

2461. Binoxalate of Potash. *Roberts, Dale, & Co.*

2462. Deacon's Apparatus for exposing porous materials and currents of gases to mutual action. Sectional working model, illustrating the application of one form of the apparatus to Deacon's process for producing chlorine. *Henry Deacon.*

In this example, the layer or "wall" is vertical and circular, and forms a section of a cylinder. The frames resemble those of venetian blinds, with the laths inclined at an angle of 45°, and so far apart, that an imaginary line joining the upper edge of each lath and the lower edge of the one above it is more horizontal than the natural angle of repose of the porous material itself, which is thus retained and supported by each lath in succession. A "wall" of this kind on being raised in height adds to the pressure on the bottom layers only so long as the height is less than that of a cone whose base is the width of the "wall," and whose sides are at the same angle as the natural angle of repose of the material. This increase of pressure diminishes

in inverse proportion to the height, and ceases when the height of the imaginary cone is reached, all the weight of additional height above that point being borne by the retaining frames. In the model, the "wall" and framework are in a cast-iron vessel, which is heated in a brick furnace. The porous material is distributed to, and gathered from, the wall, by covering and inverted cones from, and to, central pipes. The gaseous current passes from the outside of, and through, the "walls" to the space they and the covering cone enclose, and is withdrawn from this space, or the direction of the current is reversed at pleasure.

2463. Carbolic Acid, chemically pure, free from taste and smell of tar, and fusing at 108° Fahrenheit. Specially prepared for internal medicinal use. *F. C. Calvert & Co.*

2464. Carbolic Acid, commercial, fusing at 95° Fahrenheit. Specially prepared for external medical application.
F. C. Calvert & Co.

2465. Cressylic Acid, used for disinfecting purposes.
F. C. Calvert & Co.

2466. Sulpho-Carbolates. A series of pharmaceutical products, comprising sulpho-carbolates of potash, soda, ammonia, lime, iron, copper, and zinc. *F. C. Calvert & Co.*

2467. Carbolic Acid Preparations, comprising carbolic acid soap, carbolic acid disinfecting powder, and carbolised tow.
F. C. Calvert & Co.

2468. Picric Acid Crystals and paste, aurine, rosolic acid. Used in the arts. *F. C. Calvert & Co.*

2469. Drawings (4) of Hargreaves and Robinson's Sulphate of Soda Apparatus. 1. General plan. 2. Enlarged sectional plan. 3. Transverse sectional plan. 4. Condensing apparatus. Accompanied by—

2470. Samples of: A. Salt prepared for the converting cylinders above. B. Sulphate of soda. C. Hydrochloric acid.
J. Hargreaves & T. Robinson.

Sulphurous acid, steam and air, are made to react upon salt directly, producing sulphate of soda and hydrochloric acid, without the preliminary manufacture of sulphuric acid. The salt is placed in the iron cylinders, and the mixture of sulphurous acid, air, and steam passed through it. The evolved hydrochloric acid is taken out at the bottom of the cylinders, and conveyed to the condensers.

2471. Samples illustrative of Mond's process for the recovery of sulphur from alkali (vat or tank) waste:
1. Alkali (vat or tank) waste before oxidation.
2. Alkali (vat or tank) waste after oxidation.

...r liquor.
...pitated sulphur.
5. Sulphur in bulk.
6. Roll sulphur.

John Hutchinson & Co.

2472. Samples of Bicarbonate of Soda unground; also ground and dressed. *John Hutchinson & Co.*

2473. Specimens ... ystals.
...an Rijn, Venlo, Netherlands.

3 Crystals of potash-alum.
3 " " "
10 " " "
4 Crystals of chrome-alum.
2 " " " ...red with potash-alum.
1 Crystal of potash-alum o... kilo.
1 " " " ... kilo.

2474. Clement Winkler's ...paratus. *Robert Galloway.*

This apparatus is for the technical analysis of gases, and may be fairly termed a gas burette.

2475. Chemicals for use in various Manufactures.

Liquid archill, made from Orchella weed, for dyers and printers.
Sulphate of alumina, for sugar refiners, paper makers, and dyers.
Aluminous cake, for paper makers.
Cudbear, made from Orchella weed, for dyers.
Bichromate of potash, with samples of chrome ore, limestone, and sulphate of potash, from which it is made.

W. J. Norris and Brother.

2476. Aniline and other Chemical Products used for Dyeing. *Brooke, Simpson and Spiller.*

		Commercial Name
Rosaniline base	$C_{20}H_{19}N_3, H_2O$	—
Rosaniline hydrochlorate	$C_{20}H_{19}N_3HCl$	Roseine crystals.
Crysaniline	$C_{20}H_{17}N_3$	Phosphine.
Methyl-rosaniline acetate	$\left.\begin{matrix}C_{20}H_{18}\\CH_3\end{matrix}\right\} N_3 \Big\} C_2H_3O_2$	Hofmann violet.
Tri-methyl rosaniline acetate	$\left.\begin{matrix}C_{20}H_{16}\\CH_3\\CH_3\\CH_3\end{matrix}\right\} N_3 \Big\} C_2H_3O_2$	Eclipse violet.
Dimethyl-phenyl-rosaniline acetate	$\left.\begin{matrix}C_{20}H_{16}\\C_6H_5\\CH_3\\CH_3\end{matrix}\right\} N_3 \Big\} C_2H_3O_2$	Spiller purple.
Phenyl-rosaniline hydrochlorate	$\left.\begin{matrix}C_{20}H_{18}\\C_6H_5\end{matrix}\right\} N_3 \Big\} HCl$	Imperial violet.

		Commercial Name.
l-rosaniline hydrochlo- - - - -	$\left.\begin{matrix}C_{20}H_{16}\\ C_6H_5\\ C_6H_5\\ C_6H_5\end{matrix}\right\} N_3 \Big\} HCl$	Pure opal blue.
i-phenyl-rosaniline sul- - - - -	$\left.\begin{matrix}C_{20}H_{16}\\ C_6H_5\\ C_6H_5\\ C_6H_5\end{matrix}\right\} N_3 \Big\} NaSO_3$	Fast blue, 6B.
-rosaniline sulphonic - - - -	$\left.\begin{matrix}C_{20}H_{16}\\ C_6H_5\\ C_6H_5\\ C_6H_5\end{matrix}\right\} N_3 \Big\} HSO_3$	—
phenyl-rosaniline sul- - - - -	$\left.\begin{matrix}C_{20}H_{18}\\ C_6H_5\end{matrix}\right\} N_3 \Big\} NaSO_3$	Alkali violet.
rosaniline acetate -	$\left.\begin{matrix}C_{20}H_{17}\\ C_6H_5\\ C_6H_5\end{matrix}\right\} N_3 \Big\} C_2H_3O_2$	Atlas blue.
ri-phenyl-rosaniline di- te - - - - -	$\left.\begin{matrix}C_{20}H_{16}\\ C_6H_5\\ C_6H_5\\ C_6H_5\end{matrix}\right\} N_3 \Big\} Ca(SO_3)_2$	Soluble blue.
aniline hydrochlorate - - - - -	$\left.\begin{matrix}C_{20}H_{18}\\ CH_3\end{matrix}\right\} N_3 \Big\} HCl$	Hofmann violet cake R.
rosaniline hydrochlo- ed) - - -	$\left.\begin{matrix}C_{20}H_{17}\\ CH_3\\ CH_3\end{matrix}\right\} N_3 \Big\} HCl$	Hofmann violet cakeBB.
hydrochlorate (fused) -	$C_{20}H_{19}N_3HCl$	Roseine cake.
-rosaniline methyl io- - - - -	$\left.\begin{matrix}C_{20}H_{16}\\ CH_3\\ CH_3\\ CH_3\end{matrix}\right\} N_3 \Big\} (CH_3I)^3$	Iodine green crystals.
e - - - - -	$C_{14}H_{10}$	Anthracene.
- - - -	$C_{14}H_8O_4$	Alizarin (blue shade).
purin - - -	$C_{14}H_8O_5$	Alizarin (red shade).

. Soda Waste, Alkali Waste, Black Ash Waste, or Vaste. Insoluble residue formed in the second or black e of Leblanc's process for obtaining soda from common

John Hutchinson & Co.

ne appended analysis by Kopp of a sample it will be seen that a ntity of sulphur is present in the waste. A part of this can be extracted by Mond's and other processes.

Sulphide of sodium - - -	2,880
Carbonate of lime - - -	13,636
Silicate of lime - - - -	5,680
Hydrate of lime - - - -	8,588
Monosulphide of calcium - -	22,162
Alumina, magnesia - - -	1,466
Sulphide of iron - - -	2,670
Carbon - - - - - -	1,800
Sand - - - - - -	2,000
Water - - - - - -	36,700
Combined water and loss - -	2,418

, Oxidized Soda, Alkali, or Vat Waste.

John Hutchinson & Co.

d's process a current of air at the ordinary temperature is forced he waste as it lies in the vats, directly the last soda liquors are ray. The waste becomes hot, oxydizing, and forming polysulphides , hyposulphite and hydrosulphate of calcium. The waste is then and the liquid removed, the residue being again treated as above nes.

ulphur Liquor, the soluble portion of **Oxydised Thick Waste.** *John Hutchinson & Co.*

The ... ed waste, lixiviated in the vats with warm water, gives a yellow solution containing polysulphides of calcium, hyposulphite of calcium, and hydrosulphate of calcium.

Liquor generally contains equal to 5·0 of sulphur, distributed as follows:—

2·0 hyposulphite of calcium.
2·0 polysulphide do.
1·0 hydrosulphate do.

2480. ... formed when sulphur liquor and muria... *John Hutchinson & Co.*

Sulphur liquor is mixed ... hydrochloric acid from the condensers, the mixe... 140° Fahr, and well stirred.

The muriatic ... calcium in the liquor, sulphur is deposited as a ...

In a good ... of ... all ... lphide of hydrogen disengaged by decomposit... sulphurous reacts ... the sulphurous acid liberated at the same time ... hyposulphite, sul... and water being the products.

2481. Lump Sulphur, ... pared by melting the moist sulphur of a previous stage of ... process in a strong cast-iron vessel. *John Hutchinson & Co.*

After washing out the chloride of calcium from the moist sulphur, the drained product is put into a strong cast-iron cylinder, the filling-in aperture screwed down, and steam of a pressure of 35 lbs. admitted through a coil of cast-iron pipe. The sulphur rapidly melts, and at the expiration of a certain time, found out by experience, the whole charge is forced by the pressure of the steam through the discharge pipe into tight wooden wagons, and when cool broken up for sale.

2482. Roll Sulphur. The roll brimstone of commerce, used in medicine. *John Hutchinson & Co.*

Melted sulphur run into round wooden moulds and allowed to cool.

2483. Bicarbonate of Soda (lump), prepared by exposing crystals of carbonate of soda to a current of carbonic acid gas till saturated, and drying the product. *John Hutchinson & Co.*

The dry lump bicarbonate ground in a mill and dressed to separate coarse particles, as in grinding and preparing flour from wheat.

2484. Bicarbonate of Soda. Carbonate of soda of the shops, used in medicine and for making effervescing drinks. *John Hutchinson & Co.*

Soda crystals, or carbonate of soda, made by dissolving the soda-ash of Leblanc's process in hot water, and, after settling, allowing to cool and crystallize, are put in an air-tight iron chamber, and carbonic acid gas (prepared by decomposing limestone with waste muriatic acid from the condensers) turned in by a pipe on the roof of the chamber. After some hours the crystals are changed into bicarbonate of soda, part of the water of crystallization escaping during the process

The moist bicarbonate is dried in kilns heated not over 100° Fahrenheit

COLLECTION OF PREPARATIONS RESULTING FROM TECHNICAL AND SCIENTIFIC RESEARCH. CONTRIBUTED BY MEMBERS OF THE GERMAN CHEMICAL SOCIETY. (The names of the members are given below their contributions).

2677.

1. Anthracene.
2. Anthraquinone.
3. Dinitrobenzene.
4. Eosine potassium.
5. Methyl Violet.
6. Rubin (Rosanilinchlorhydrate).
7. Benzylchloride.
8. Aniline.
9. Hydrochlorate of Safranine.
10. Hofmann's Violet (Iodine Violet).
11. Toluene.
12. Coralline (Ammonium-rosolate).
13. Nitrobenzene.
14. Aurine (Rosolic acid).
15. Phenylene Brown.
16. Azobenzol.
17. Phosphine (Nitrate of Chrysaniline).
18. Nitronaphthaline.
19. Picric acid.
20. Diphenylamine.
21. Rosanilinbase.
22. Methyl Green, crystallized.
23. Nitrotoluene, solid.
24. Phtalic acid.
25. Toluidine, liquid.
26. Aniline Blue, soluble (Sodium-triphenylrosaniline-sulfate).
27. Toluidine, crystallized.
28. Phenol, crystallized.
29. Dimethylaniline.
30. Aniline Blue (Triphenylrosaniline-chlorhydrate).
31. Martius Yellow (Dinitronaphthol-calcium).
32. Dinitrocresol potassium.
33. Benzene, crystallized.
34. Naphtol.
35. Naphtylamine.
36. Methyldiphenylamine.
37. Naphtalene.
38. Aurantia.
39. Nigrosin, soluble in spirits.
40. Nigrosin, soluble in water.
41. Magdala-Red.
42. Mauve.
43. Cresol.

The compounds are intended for illustrating the present state of the coal-tar colour manufacture, and the above collection embraces all the preparations of this class manufactured at present.

Actien-Gesellschaft für Anilinfabrikation, Rummelsburg, near Berlin.

Monochlorcresol $C^6H^3\left\{\begin{matrix}CH^3\\Cl\\OH\end{matrix}\right.$ (Fusing point 56°.)
Mesitol $C^6H^2(CH^3)^3OH$. (Fus. p. 68°—69°.)
Nitronaphtol-Potassium $C^{10}H^6(NO^2)OK$.
Nitronaphtol-Sodium $C^{10}H^6(NO^2)ONa + 2H^2O$.
Nitronaphtol-Barium $[C^{10}H^6(NO^2)O]^2Ba + H^2O$.
Nitronaphtol-Lead $[C^{10}H^6(NO^2)O]^2Pb$.
Bibromnaphtol $C^{10}H^5Br^2(OH)$. (F. p. 111°.)
Mononitrophenylendiamine $C^6H^3(NO^2)(NH^2)^2$.

Dr. Rud. Biedermann, Berlin.

Magnesium-platino-cyanide $Mg\,Pt\,(CN)_4$
Magnesium carbonate (crystallised).
Benzomonochloride $C_6H_5CH_2Cl$.
Benzodichloride $C_6H_5CHCl_2$.
Benzotrichloride $C_6H_5CCl_3$.
Monochlortoluol $C_6H_4ClCH_3$.
Monochlorbenzylchloride $C_6H_4ClCH_2Cl$.
Benzylsulphhydrate $C_6H_5CH_2SH$.
Benzylsulphide $(C_6H_5CH_2)_2S$.
Mercury-Benzylsulphide $(C_6H_5CH_2S)_2Hg$.
Benzylsulphoxyde $(C_6H_5CH_2)_2SO$.
Benzylsulphoxyde and very remarkable from their different power of crystallization.
Disulphobenzyle $(C_6H_5CH_2)_2S_2$.

H_{18}.

ne

$C_6H_5COC_6H_3(CH_3)_2$.

ic acid

$H_5COC_6H_3(COOH)_2$.

Benzoylisophtalate of barium
$C_6H_5COC_6H_3BaH_2O$.

Benzoylisoph ate of Ethyl
Benzoylisophtalate of Methyl
$C_6H_5COC_6H_3\begin{cases}COOC_2H_5\\COOC_2H_5\end{cases}$

Isomeric
phtalic ac

The lead pr

Benzylisophtalic acid
$C_6H_5CH_2C_6H_3(COOH)_2$.

Benzylisophtalic acid, Barium, Calcium.

Barium-Ethylsulphate, $Ba\begin{cases}C_2H_5SO_4\\C_2H_5SO_4\end{cases}$

(Crystals of rare beauty.)

Anthracene.

Red Chromate of lead.

Green Chromate of lead.

Yellow Chromate of lead (chemically pure).

rkish red.

means of chemically pure Ceruse.

Aug. Blatzbecker, Cologne.

Elaidic Acid. mann, Verden. Obtained from the oleine of stearin, it once in cold and once in heat.

Angelic acid; well shaped crystals, 1·2 cm. long, 3 mm. thick $C_5H_8O_2$.

Sodium-Ethylhyposulphite
$SO_2\begin{cases}C_2H_5\\ONa\end{cases}$

Taurine Crystals, 5 cm. long
$C_2H_7NSO_3$.

Cubebene-Stearoptene $C_{15}H_{26}O$.

Hydrochlorate of Cubebene
$C_{15}H_{24}HCl$.

Hydrochlorate of Turpentine
$C_{10}H_{16}HCl$.

Terpin $C_{10}H_{20}O + H_2O$

Chelidonic acid $C_7H_4O_6 + H_2O$.

Bromalhydrate crystals, long 4 cm., high 2 cm., thick 1 cm. $C_2HCl_3OH_2O$.

Arbutine $C_{25}H_{34}O_{14}$.

line cyanide CNI.

rium-Amylsulphate
$(SO_4C_5H_{11})_2Ba$.

Potassium-dichloracetate
C_2HCl_2KO.

Potassium-Stannocyanide
$Sn(CN)_2 2KCN$.

Ethyl-dichloracetate $C_2HCl_2C_2H_5O$.

Octyl-Butyrate, Ethereal oil of Pastia.

Octyl-Butyrate, Ethereal oil of Heracleum Sphondyl

Octylalcohol norm. $C_8H_{18}O$.

Octylacetate norm $C_8H_{17}OC_2H_3O$

Iodine-trichloride-potassium-chloride
$KClICl_3$

Breslau, Pharmaceutical Institute of the University of; Prof. Dr. Poleck and Dr. Hulva.

Tetramethylammoniumtriiodide
$(CH_3)_4NI_3$.

Tetramethylammoniumpentaiodide
$(CH_3)_4NI_5$.

Trimethylethylammoniumtriiodide
$(CH_3)_3(C_2H_5)NI_3$.

Trimethylethylammoniumpentaiodide $(CH_3)_3(C_2H_5)NI_5$.

Methyltriethylammoniumtriiodide
$(CH_3)(C_2H_5)_3N_5I_3$.

Tetraethylammoniumpentaiodide
$(C_2H_5)_4NI_5$.

Tetraethylammoniumtribromide
$(C_2H_5)_4NBr_3$.

Molybdenumdichloride Mo_2Cl_4.

Molybdenumdichloride $Mo_2Cl_4 3H_2O$.

Molybdenumtrichloride Mo_2Cl_6.

Molybdenumtetrachloride $MoCl_4$.

Molybdenumpentachloride Mo_2Cl_{10}.

Molybdenum-oxychloride MoO_2Cl_2.

Molybdenum-oxytetrachloride
$MoOCl_4$.

The Polyiodides of the ammonium-bases are resulting from the researches of Weltzien.

The Molybdenum-chlorides and oxychlorides are prepared by Liechti and Kempe.

The large tube of Molybdenum-pentachloride has been prepared recently by Aronheim and Bornemann.

Carlsruhe, Chemical Laboratory of the Polytechnic Academy; Prof. L. Meyer.

phenylchloride $C_6H_5PCl_2$.
phenyltetrachloride $C_6H_5PCl_4$.
phenylchlorobromide $C_6H_5PCl_2Br_2$.
phenylchlorotetrabromide $C_6H_5PCl_2Br_4$.
phenyloxychloride $C_6H_5PCl_2O$.
phenylic acid $C_6H_5PO(OH)_2$.
ium-phosphenylate $C_6H_5PO(O_2Ca)$.
phenylous acid $C_6H_5PO(OH)H$.
hlortolylphosphinic acid $C_6H_4CCl_3PO(OH)_2$.
Diethylphenylphosphine $C_6H_5(C_2H_5)_2P$.
Monophenylphosphoric chloride $POCl_2(OC_6H_5)$.
Diphenylphosphoric chloride $POCl(OC_6H_5)_2$.
Monophenylphosphoric acid $PO(OC_6H_5)(OH)_2$.
Phosphorchlorotetrabromide PCl_3Br_4.
Amidophosphenylic acid $C_6H_4(NH_2)PO(OH)_2$.
Nitrophosphenylic acid $C_6H_4(NO_2)PO(OH)_2$.

Carlsruhe, Chemical Laboratory of the Polytechnic Academy; Prof. A. Michaelis.

Chlorbromacetic acid.
Chloral-cyanide-cyanate.
Chloral-anilide.

Dr. C. V. Cech, Berlin.

Triphenylbenzene }
Triphenylbenzene } different crystallisations.
Triphenylbenzene }
Sulphide of benzophenone.
Triphenylic ether.
Crystallized Pinakon of the Acetophenone.

Prof. Engler, Halle.

nzoic acid sublimed from urine. Fine crystals with scarcely any smell; ssing a pure white colour.

Furtenbach and Oelhafen, in Reichelsdorf near Nuremberg.

monium bicarbonate $CO\begin{cases}OH\\ONH^4\end{cases}$ This compound, hitherto found in the ng apparatus of gas manufactories where the apparatus has the temure of the surrounding air, is interesting on account of its having been red in the gas-discharge pipes of hydraulic machines. The pipes have nperature of 50° C. and upwards, at which temperature carbonate of nia for the most part dissociates into its components. No iodine was in the compound; the dark colour was owing to coal-dust.
alic acid from lighting gas, $C^2O^4H^2,2H^2O$, obtained by treating larger ities of coal-gas with fuming nitric acid, after having withdrawn from the e vapours of hydrocarbons by means of intense cold.
s from lighting gas from Silesian coals obtained in very small quantity posure of large quantities of lighting gas to the intense cold of −21° R.

Gaswerke Städtische, Berlin (Dr. Tieftrunk).

Stannous chloride, Tin salt, $SnCl^2 + 2H^2O$ chemically pure, contains 52 ent. of Sn.
Stannic chloride, $SnCl_4 + 5H_2O$, contains 43 per cent. of Sn.
Sodium-stannate contains 42–44 per cent. of Stannic oxide in soluble $Na_2SnO_3 + 2H_2O$.

Th. Goldschmidt, Berlin.

first Boron ever made, Bo.
" Aluminium, Al.
" Urea, $CO(NH_2)_2$.
Wolfram phosphide.
Silicon-calcium.
Amorphous Silicon, from Silicon-hydride.
Titaniumcyanochloride $TiCl_4CNCl$.
Chromic oxide Cr_2O_3.
Cyanotitaniumnitride Ti_5CN_4.
Crystal of Arsenous anhydride As_2O_3.
Silicon-Nitride
Phosphoruscyanide $P(CN)_3$.
* Bariumorthonitrobenzoate $(C_6H_4(NO_2)(NO_2)^oCOO)_2Ba + 3H_2O$.
* Ethylorthonitrobenzoate $C_6H_4(NO_2)oCOOC_2H_5$.
Sodiummetanitrobenzoate $C_6H_4(NO_2)^mCOONa + 3H_2O$.
* Ethylmetanitrobenzoate $C_6H_4(NO_2)^mCOOC_2H_5$.
* Bariummetanitrobenzoate $(C_6H_4(NO_2)^mCOO)_2Ba + 4H_2O$.
* Bariumparanitrobenzoate $(C_6H_4NO_2)^pCOO)_2Ba + 5H_2O$.
*Ethylparanitrobenzoate $C_6H_4(NO_2)^pCOOC_2H_5$.
Sodiumsulphbenzoate $C_6H_4COOHSO_2ONa$.
Orthonitrobenzanilide from Benzanilide $C_6H_4\left\{\begin{matrix}NO_2^o\\NH\end{matrix}\right.(COC_6H_5)$.
Metanitrobenzanilide, from Benzanilide $C_6H_4\left\{\begin{matrix}NO_2^m\\NH\end{matrix}\right.(COC_6H_5)$.
Paranitrobenzanilide, from Benzanilide $C_6H_4\left\{\begin{matrix}NO_2^p\\NH\end{matrix}\right.(COC_6H_5)$.
Tetrabromtoluene $C_6H_4CH_3Br^p$.

Those bodies marked with * are prepared for the crystallographic investigation of isomeric compounds.

Gottingen; Universitäts Laboratorium (Prof. Wöhler and Prof. Hübner).

1. Triacetonamine.
2. Triacetonamine nitrate.
3. Triacetonamine sulfate.
4. Triacetonamine oxalate.
5. Triacetonamine bioxalate.
6. Chlorhydrate of Triacetonammonium platinochloride.
7. Chlorhydrate of Triacetonammonium-platinochloride.
8. Diacetonamine nitrate.
9. Diacetonamine binoxalate.
10. Chlorhydrate of Tri-isotriacetonammoniumplatinochloride.
11. Diacetonammoniumplatinochloride.
12. Diacetonic alcohol.

Prof. Dr. W. Heintz, Halle a. S.

Metallic modification of phosphorus; the crystalline leaves are on lead and isolated from the lead by means of diluted nitric acid.

Prof. W. Hittorf, Munster, Westfalia.

1. Dimethylammoniumchloride.
2. Trimethylammoniumchloride.
3. Tetramethylammoniumiodide.
4. Diethylamine.
5. Triethylamine.
6. Tetraethylammoniumiodide.
7. Ethylenediaminechlorhydrate.
8. Monophenyloxamide.
9. Phenylated diacetamide.
10. Formamide.
11. Phosphoniumiodide.
12. Ethylphosphoniumiodide.
13. Dibenzylphosphine.
14. Ethenyldiphenyldiamine.
15. Melaniline.
16. Melanilinnitrate.
17. Melanilinsulphate.
18. Diphenylparabanic acid.
19. Ethylic sulfocyanate (Ethyl-mustardoil).
20. Methylic sulfocyanate (Methyl-mustard oil).
21. Phenylic sulfocyanate (Phenyl-mustardoil).
22. Allylacetate.
23. Allylalcohol.
24. Allylamine.
25. Allylsulphide.
26. Carbanilide.
27. Sulphocarbanilide.

28. Cyananiline.
29. Monobromaniline.
30. Toluylendiamine.
31. Dinitrobenzene.
32. Base from the residues of the Aniline manufacture, $C_{19}H_{26}N_2$.
33. Toluidinehydroxalate.
34. Toluidinechlorhydrate.
35. Toluidinesulphate.
36. Melanilinehydroxalate.
37. Toluylic acid from Lepidium sativum.
38. Nitrophenol.
39. Rosanilinchlorhydrate.
40. Iodine-combination of Methyl-green.
41. Potassium salt of Eosine.
42. Xylidine pure.
43. Tetraphenylmelamine.

Prof. A. W. Hofmann, Berlin.

Collection of Substances discovered by Liebig.

Bariumperoxyd.
Phosphorus nitride.
Nitrogen chlorophosphide.
Acetal.
Acetone.
Aldehydeammonia.
Metaldehyde.
Formic acid.
Asparagin.
Asparic acid.
Aethylenechloride.
Butyric acid.
Calciumchloride, Acetic ether.
Carbothialdine.
Comenic acid.
Chloral.
Chloralhydrate.
Citraconic acid.
Acetate of Ethyle.
Lactose.
Sodium ethylate.
Barium methionate.
Manganeseoxalate.
Oxalate of Ethyle.
Ferrous oxalate.
Oxamate of Ethyle.
Oxamide.
Mercaptide of mercury.
Cane sugar.
Stearic acid.
Mucic acid.
Thialdine.
Vinylphosphate of barium.
Vinylsulphate of barium.
Vinylsulphate of calcium.
Tartaric acid.
Potassium-cyanate.
Cyanuric acid.
Fulminate of ammonium.
Fulminate of barium.
Persulphocyanic acid.
Sulphocyanate of silver.
Sulphocyanate of potassium.
Sulphocyanate of ammonium.
Urea.
Mercuric oxyde-urea.
Uric acid.
Alloxane.
Alloxanate of barium.
Alloxantine.
Allantoine.
Ammeline-nitrate.
Ammelide.
Dialurate of ammonium.
Melam.
Melamine.
Mellonate of potassium.
Mesoxalate of barium.
Murexide, pure.
„ commercial.
Oxalurate of ammonium.
Parabanic acid.
Uramil.
Kreatine.
Sarkosinechlorhydrate.
Thionurate of ammonium.
Xanthogenate of potassium.
Benzoic aldehyde.
Benzoylchloride.
Benzoylbromide.
Benzoylcyanide.
Benzoyliodide.
Benzil.
Benzilic acid.
Benzoin.
Benzoate of Ethyle.
Mandelic acid.
Picric acid.
Atropine.
Brucine.
Caffeine.
Chinchonine.
Morphine.
Meconic acid.

Acidum Benzoicum ex urina, $\left.\begin{matrix} C_7H_5O, \\ H \end{matrix}\right\} O.$

Kaufmann's manufactory of Benzoic acid is the largest on the Continent.

Karl Joseph Kaufmann, Königsberg, in Prussia.

Sinistrin.
Albumin, soluble from barley.
Albumin, coagulated from barley.
Oil fatty, from barley.
Sugar from barley in form of syrup.
Sugar from barley crystallised.
Cerealic acid.

Dr. G. Kühnemann, Dresden (later Görlitz).

1. Didymiumsulfate.
2. Iridium-sodium-sesquichloride.
3. Rhodium-sodium-sesquichloride.

Used for measuring the crystals.

Prof. von Lasaulx, Breslau.

One specimen of bromine.
One specimen of bitter salt.
Two specimens of magnesiumchloride.
One specimen of potassiumchloride, 98 per cent.
One specimen of potassiumchloride, 80 per cent.

Leopoldshaller Vereinigte chemische Fabriken, Actien-Gesellschaft, Leopoldshall near Stassfurt.

1. Cörulignone $C_{16}H_{16}O_6$.
2. Hydrocorulignone $C_{16}H_{18}O_6$. White in small crystals.
3. Hydrocorulignone $C_{16}H_{18}O_6$. Brownish in large crystals.
4. Bibromanthracenetetrabromide $C_{14}H_8Br_6$.
5. Bibromanthracene $C_{14}H_8Br_2$.
6. Tetrabromanthracene $C_{14}H_6Br_4$.
7. Anthraquinone $C_{14}H_8O_2$.
8. Anthracene $C_{14}H_{10}$. Blue fluorescence.
9. Chrysene (yellowish) $C_{18}H_{12}$.
10. Chrysene (white) $C_{18}H_{12}$.
11. Chrysoquinone $C_{18}H_{10}O_2$.
12. Xylindein
13. Monooxyanthraquinone $C_{16}H_8OH \cdot O_2$
14. Dichloranthracene $C_{14}H_8Cl_2$.
15. Binitroanthraquinone $C_{14}H_6(NO_2)_2O_2$.
16. Biamidoanthraquinone Sublimed. $C_{14}H_6(NH_2)_2O_2$.
17. Hydrochrysamide $C_{14}H_2(NH_2)_4(OH)_2O_2$.

Professor C. Liebermann, Berlin.

1. *Hyoscyamine crystals.*—Crystallised alkaloid from Hyoscyamus niger and alb., produced for the first time in larger quantities and brought into the market; crystallised in snow-white needles. According to the investigations of Dr. Harnack at Strassburg, and Dr. Fronmüller in Fürth (which, however, have not yet been brought to a conclusion), this preparation is exceedingly effective, and is in this respect almost equal to atropine.

The smallest dose which paralyses the termination of the vagus of the heart of a frog, consists of 1/200 milligramme (0·000005). (Raising of the suspended beating of the heart by Muscarin) the dose which still produces enlargement of the pupil of a rabbit, is 1/250 milligramme (0·000004) [Harnack].)

2. *Amorphous Hyoscyamine.*—Amorphous alkaloid from Hyoscyamus niger and alb. The smallest dose which paralyses the terminations of the vagus of the heart of a frog is in this instance 1/100 milligramme (0·000001, Harnack).

3. *Ditaine crystal.*—Crystallised bodies from the cortex dita of Echites scholaris, only recently introduced into medicine.

4 -Amorphous alkaloid from the same bark. Both bodies quite nev They represent the effective substances of this drug.

5. *Kamalin crystal.*—Crystallised body from Kemala, the fibres and glands of the fruit of Rottlera tinctoria. Effective substance of this drug. New in trade.

6. *Muscarin nitricum.*—Nitrate of the alkaloid contained in the toadstool (Agaricus arius). Muscarin is likewise new in commerce.

7. *Piloc* .—Alkaloid from the leaves of Policarpus pinnatifolius, *Saborandi*, since a short time only employed in medicine. New in commerce.

8. *Veratric cid.* from the seeds of Sabadilla.

9. *Koso cry* iciple of the Koso plant crystallises partly in needles, prisms belonging to the rhombic system. Almost insoluble in easily dissolved in ether, benzol, sulphide of carbon, and chlorofor s easily in glacial acetic acid and alcohol.

For further particulars *see* Schroff, Ausstellungsbericht" (Vienna), page 32; Flückiger, "Archiv der Pharmacie," 1874, part 2, and "Pharmaceutical Journal, transactions, 1875, No. 289."

10. *Apomorphia hydrochlor. crystal.*— re and certain acting preparation, *see* Harnack, "Archiv für experiment Pathologie und Pharmakologie." Dr. Juratz, "Zeitschrift für Medizin."

Emanuel Merck, Darmstadt.

1. Telluric acid $H_2T_2O4+4H_2O$.
2. Tellurous anhydride T_2O_3.
3. Iodbromide of mercury HgIBr.
4. The same, larger crystals.
5. Phosphide of cadmium.
6. Methyl benz acetol $CH_3-C(C_7H_5O_2)_2-CH_3$. Prepared from monochlorpropylenebydrate by means of silverbenzoate.
7. Menthol $C_{10}H_{19}OH$.
8. Menthyl acetate $C_{10}H_{19}OC_2H_3O$
9. Menthene $C_{10}H_{18}$.
10. Borneol $C_{10}H_{17}OH$ (natural).
11. Benzoic aldehyde $C_7H_{6}O$. Prepared synthetically from $C_6H_5CHCl_2$ by means of sulphuric acid.
12. Phthalic anhydride $C_8H_4O_3$. Large crystals formed by slow decomposition of the chloride in moist air
13. Ethyl aceto-acetate $CH_3COCH_2COOC_2H_5$ Prepared synthetically from acetic ether.
14. Dehydracetic acid $C_8H_8O_4$.
15. Oxyuvitic acid $C_9H_8O_5$ Prepared synthetically from acetic ether.
16. Metacresol C_7H_7OH Prepared synthetically from acetic ether
17. Metacresol-ethylic ether $C_7H_7OC_2H_5$. Prepared synthetically from acetic ether.
18. Oxybenzoic acid $C_6H_4OHCOOH$ Prepared synthetically from acetic ether.
19. Methyl-oxybenzoic acid $C_6H_4OCH_3COOH$.
20. Methyloxybenzoate of calcium $(C_6H_4OCH_3COO)_2Ca+4H_2O$.
21. Hydro-oxybenzoic acid $C_6H_4OHCOOH$.
22. Cresotic acid $C_7H_6OHCOOH$.
23. Trinitrocresol $C_7H_4(NO_2)_3OH$.

Prof. A. Oppenheim, Berlin.

Butylchloral $C_4H_5Cl_3O$.
Butylchloral-hydrate $C_4H_7Cl_3O_2$.
Trichlorbutyric acid $C_4H_5Cl_3O_2$.
Chlorangelactic acid $C_5H_7ClO_3$.
Chloralcyan-hydrate $C_3H_2Cl_3NO$.
Trichlorolactate of ethyl $C_5H_7Cl_3O_3$.
Chloracrylate of ethyl $C_5H_7ClO_2$.
Bromalcyanhydrate $C_3H_2Br_3NO$.

Dr. A. Pinner, Berlin.

Chloralhydrate, large crystals
Chloralhydrate, small crystals
Chloralhydrate, in powder -
Chloralhydrate, in crusts -
} $C_2HCl_3O + H_2O$.

Chloroform from Chloral, $CHCl_3$.

All these preparations are perfectly pure, the chloralhydrate being a special product of the manufactory.

Saame and Co., Ludwigshafen on the Rhine.

Phenol, pure, is perfectly free from cresol, and therefore *perfectly* soluble in 20 times its quantity of water.

Phosphoric acid, chemically pure; the commercial so-called fused phosphoric acid contains up to 25°/o sodium-pyrophosphate.

Salicylic acid cryst., perfectly soluble in water, alcohol, and ether.

Salicylic acid subl.

Tannin leviss. contains only a very trifling quantity of glucose, is therefore, according to H. Schiff, nearly pure digallic acid.

Monobromcamphor.

Trichloride of carbon.

Salicylate of quinine.

Chloralhydrate in plates.

Chloralhydrate in crystals, prepared according to the special directions of O. Liebreich, perfectly free of other chlorinated compounds, and is unchangeable for years.

Chloralide.

Butylchloral.

Saccharate of iron, soluble, not containing any free sugar, but a pure chemical compound of ferric oxyde, soda, and sugar.

Bromide of potassium, entirely unaffected by barium salts.

Iodide of potassium, like the above, and free from iodic acid, therefore entirely unchangeable.

Potassium hydrate.

Permanganate of potassium.

Salicylate of sodium, easily soluble in water and alcohol.

Salicylate of zinc.

E. Schering, Berlin.

Hyposulphite of sodium $Na_2S_2O_6 + 2H_2O$.

Hyposulphite of barium $BaS_2O_6 + 4H_2O$.

Hyposulphite of strontium $SrS_2O_6 + H_2O$.

Hyposulphite of lead $PbS_2O_6 + 4H_2O$.

Selenium, precipitated.

Cube of selenium.

Tellurium in rods Te.

Tellurium in cubes.

Telluric acid H_6TeO_6.

Iodide of carbon CI_4.

Silicon-sulphide SiS_2.

Chlorate of sodium, three different crystalline forms, $NaClO_3$.

Periodate of sodium $NaIO_4 + 3H_2O$.

Arseniate of sodium $HNa_2AsO_4 + 24H_2O$.

Lithium in wire, Li.

Lithium in balls, Li.

Lithium in bars.

Beryllium metal Be.

Berylliumchloride, sublim, $BeCl_2$.

Sulphate of Beryllium $BeSO_4 + 2H_2O$.

Nitroprusside of sodium $Cy_5Fe_2NO_2$, $2CyNa + 2H_2O$.

Zirconium metallic, Zr.

Calcium met., obtained by electrolysis, Ca.

Strontium met., obtained by electrolysis, Sn.

Yttriumplatinocyanide $YCy_4Pt + 7H_2O$.

Didymiumplatinocyanide $Di_2Cy_{12}Pt_3 18H_2O$.

Sulphate of Ceroso-ceric oxide $Ce_5S_6O_2 + 21H_2O$.

Nitrate of Cerium-magnesia $MgN_2O_6 + CeN_2O_6 + 8H_2O$.

Nitrate of Cerium-nickel $NiN_2O_6 + CeN_2O_6 + 8H_2O$.

Nitrate of cerium and didymium $DiN_2O_6 + 4H_2O$.

Oxalate of yttrium $YC_2O_4 + 4H_2O$.

Oxalate of erbium $ErC_2O_4 + 3H_2O$.

Oxalate of cerium CeC_2O_4.

Oxalate of didymium $DiC_2O_4 + 4H_2O$.

Oxalate of thorium $ThC_4O_8 + 2H_2O$.

Sulphate of thorium $ThS_2O_8 + 9H_2O$.

Manganese metal Mn.

Nickelbromide subl. $NiBr_2$.

Sulphate of nickel $NiSO_4 + 7H_2O$.

Sulphate of nickel and potash $NiSO_4 + K_2SO_4 + 6H_2O$.

S... per $CuSeO_4 + 5H_2O$.
S... pper-oxyde-ammonia $CuSO_4 + 4NH_3 + H_2O$.
Arsenious acid crystallised from hot hydrochloric acid.
Iodide of arsenic, subl. As_2I_6.
Iodide of antimony, subl. SbI_3.
Fused vanadic acid V_2O_5.
Acid vanadate of sodium $Na_2V_4O_{11} + 9H_2O$.
Acid vanadate of ...
(N...
Molybdic acid, subl. ...
Titaniumsesquichloride ...
Acetate of calcium and ...
(C_2H... (C_2H...
Sulphocarbonate of po... sium $CS<^{SK}_{SK}$
Sulphocarbonate of sodium $CS<^{SNa}_{SNa}$
Xanthogenate of sodium $CS<^{OC_2H_5}_{SNa}$
Xanthogenate of potassium $CS<^{OC_2H_5}_{SK}$
Hippuric acid $CH_2\left\{\begin{array}{l}NHC_7H_5O\\CO_2H\end{array}\right.$
Carbonate of guanidine $CH_5N_3H_2CO_3$.
Levulinate of calcium $(C_5H_7O_3)2Ca + 2H_2O$.
Nitrate of cytisine.
...thofellinic acid $C_{20}H_{36}O_4$.
Phthalic anhydride $C_6H_4\left\{\begin{array}{l}CO\\CO\end{array}\right\}O$.
...ilbene, pure $\left\{\begin{array}{l}CH-C_6H_5\\CH-C_6H_5\end{array}\right.$
...ilbene, common $\left\{\begin{array}{l}CH-C_6H_5\\CH-C_6H_5\end{array}\right.$
...iphenylbenzene $C_6H_3(C_6H_5)_3$.
...yracene $C_6H_7O_2$ ... C_2H_5.
...itrosodimethylaniline $C_6H_4(NO)N(CH_3)_2$.
...itrosodimethylaniline aniline $[C_6H_4(NO)N(CH_3)_2]_2 + C_6H_5NH_2$.
...enanthrene $C_{14}H_{10}$.
Acetophenon C_6H_5, CO, CH_3.
Benzophenon C_6H_5, CO, C_6H_5.

Cases containing 64 preparations of the metals and other elements.

Dr. Theodor Schuchardt, Görlitz in Silesia.

Coniferin $C_{16}H_{22}O_8 + H_2O$
Vanillin $C_8H_8O_3$, small crystals are in this shape, the commercial product.
Vanillin $C_8H_8O_3$, slowly crystallised from dilute solutions
Vanillin $C_8H_8O_3$, from residues of the artificial preparation of vanillin, and sublimed in the same manner as the vanillin of the Vanilla pods at the ordinary temperature.
Vanillic acid, slowly crystallised from dilute solution
Vanillic acid $C_8H_8O_4$, finely crystallised as commercial commodity.
Sugar-vanillic acid $C_{14}H_{18}O_9$, prepared by Reimer and Tiemann. The compound is crystallised in the bottle itself
Acetoeugenol $C_{12}H_{14}O_3$, prepared by Nagai and Tiemann.
Ferulic acid $C_{10}H_{10}O_4$, prepared by Nagai and Tiemann. The above acid is prepared synthetically from Vanilla; the white opaque crystals are re-crystallised from alcohol, the yellowish brilliant from water.

Tiemann, F. Dr., and Haarmann, Dr. W., Berlin and Holzminden.

$$\text{Allylic-Alcohol}\left\{\begin{array}{l}CH^2.\\CH.\\CH^2OH.\end{array}\right.$$

Prepared by distilling glycerine with oxalic acid and traces of sal ammoniac.

Tollens, B., Professor, Göttingen.

Chromic acid.
Molybdic acid, fused and sublimed specimens.
Molybdic acid, fused
Molybdic acid, sublimed.
Selenious acid.
Tellurous acid.
Tungstic acid.

: acid.
umsulphate.
romide.
eroxyde cristall.
nsulphate.
abromide.
asulphide.
-alum.
chloride fus.
rotosulphate.
ersulphate.
msulphate.
alphate.
um copper tartrate.
m copper chromate.
oxyde.
hloride, subl.
lphate.
: of iron.
sulphate.
hionate.
ite.
citrate.
sulphate.
manganese.
ese chloride.
molybdenum.
molybdate.
alphate.
mhydrate in rods.
mhydrate in cakes.
nhydrate, pure.
mnitrite.
n alum.
romate.
ydrate.
ydrate, pure.
lithionate.
phosphotungstate.
tungstic acid.
silicate, crist.
mhydrate.
n.
acarbonate.
asulphate.
asulphate.
m titanfluoride.
Tungsten.
iumtungstate.
ium Uranocarbonate.
nitrate.
b. oxid.
b. sulfate.
oride fus.
Potass. fluorid.
iummellilate.

Paramide.
Copper cyanide violet.
Copper cyanide green cryst.
Mercury-cyanide.
Barium platinocyanide.
Magnesium platinocyanide.
Potassium platinocyanide.
Potassiumcyanate.
Sulphocyanammonium.
Nitroprusside of sodium.
Cyanuric acid.
Ureanitrate.
Alloxan.
Ammonthionurate.
Carbontetrachloride.
Iodoform.
Potassium sulphomethylate.
Oxalate of methyle.
Copperformiate.
Strontiumformiate.
Butyric ether.
Capronic ether.
Ethyloxalate.
Sebacic ether.
Ethylenechloride.
Ethylenebromide.
Bariumsulphethylate.
Carbonhexachloride.
Glycol.
Aldehydeammonia.
Monochloracetic acid.
Acetamide.
Ammonium acetate.
Propylic alcohol norm.
Propylacetate.
Propionic acid from propylic alcohol.
Aceton. Natr. bisulfit.
Dichlorhydrin.
Lactic acid.
Zinc lactate.
Isobutylic alcohol.
Butyric acid from fermentation.
Amylchloride.
Bariumsulphamylate.
Valeral-sodium-bisulphite.
Capronic acid from fermentation.
Capronic acid from valerianic acid—residues.
Caprylic acid.
Caprinic acid.
Bariumcapronate.
Caprylic alcohol.
Methyloenanthol.
Capronic acid from caprylic alcohol.
Ethal.

Sebacic acid.
Malic acid.
Calciumbimalate.
Aconitic acid.
Anisic acid.
Asparaginic acid.
Camphoric acid.
Cinnamic acid.
Cuminic acid.
Fumaric acid.
Picramic acid.
Salicylous acid.
Sorbic acid.
Camphormonobromide.
Benzolbichloride.
Benzoin.
Styracin.
Styrol.
Benzoylalcohol from crude cinnamic alcohol.
Phenylpropylic alcohol.
Monochlortoluene.
Xylene.
Naphtalinbichloride.
Mesitylene
Cymene.
Chrysophanic acid.
Emodine.
Aporetin
Erythroretin.
Phaeoretin
Gentisine
Haematoxyline
Indigotin.
Tannin
Glycyrrhizin.
Melampyrite (Dulcit).
Glycocoll
Inosite
Allantoin.
Taurin.
Hyoglycocholic acid.
Aconitine.
Aesculin.
Amygdalin.
Anemonin.
Anemonic acid.
Arbutin.
Methylhydroquinone from Arbutine.
Green Hydroquinone from Arbutine.
Asaron.
Atropine.
Tropinsulphate.
Atropa acid.
Tropa acid.
Berberinnitrate.
Cantharidin.
Caffeine, raw.
Caffeine, pure crist.
Colchicin.
Columbin.
Conine.
Corydalin.
Coumarin.
Cubebin.
Daturine.
Delphinine.
Elaterine cryst.
Filicin.
Filimelissic acid.
Ononine.
Helenin.
Lactucerin
Imperatorin
Peucedanin.
Picrotoxin
Piperine
Potassiumpiperinate.
Quercitrin.
Quininvalerate
Saponin.
Solanin
Stramonine.
Syringin.
Theobromine.
Urson.
Veratrine.
Rubidiumbitartrate.

Dr. H. Trommsdorff, Erfurt.

Stafsfurt "Abraumsalz."

Potassium chloride, obtained by means of hot extraction.

Kieserite, obtained by cold lixiviation of the residues of the above process

Picromerite, obtained by action of Kieserite on Potassium chloride in the heat.

Potassium sulphate, prepared by decomposition of the picromerite by means of potassium chloride.

Potash (crude fused), by fusion of the potassium sulphate with lime and charcoal (Leblanc's Process).

Potash 95°/o, by evaporation and calcination of the leys from the above.

Potash hydrated, free from sulphuric acid; by refinement of the potash at 95°/o.

These specimens show the various stages in the preparation of potash from the mineral salts.

Vorster and Grüneberg, Kalk b. Cöln.

Amylene C_5H_{10}.
Amylhydride C_5H_{12}.
Diamylene $C_{10}H_{20}$.
Amylic Ether $C_{10}H_{22}O$.
Triamylene $C_{15}H_{30}$.

The preparations have all been manufactured from potato fusel oil (or Amylic alcohol) according to a method which allows for the preparation of starch; a continuous and comparatively cheap process of production which can also be carried out on a large scale.

Julius Weinzierl, Gr. Glogau, Silesia.

Phenoquinone $C_{18}H_{14}O_4$.
Pyrogalloquinone $C_{18}H_{14}O_8$.
Purpurogallin $C_{18}H_{14}O_9$.
Triacetamide $C_6H_9O_3N$.
Bicyannaphtalene $C_{12}H_6N_2$.
Bioxynaphtalene $C_{10}H_8O_2$.
Picric acid Bromonaphtalene $C_6H_2(NO_2)_3OHC_{10}HyBr$.
Binitronaphtalene $C_{10}H_6N_2O_4$.

Prof. Wichelhaus, Berlin.

1. Bars of nickel; 2, bars of cobalt. These metal bars are about 170mm. long and 42mm. broad and brightly polished. They form the first cast pieces of cobalt and nickel of a large size which have ever been produced, and date from the year 1866. W. Hankel made use of the same in his investigations on the magnetic bearing of nickel and cobalt. (Berichte der Königl. Sächsischen Gesellschaft der Wissenschaften, mathematisch-physische Klasse. Meeting of the 21st July 1875.)

Prof. Winkler, Freiberg, Saxony.

IV.—TECHNICAL.

2678. Digester, made of cast-steel, for digesting under pressure. It holds 4 litres, is silvered inside and coppered outside. Manufactured by Fr. Krupp, of Essen.

Professor H. Landolt, Aix-la-Chapelle.

2679. Chlorate of Potash. Muriate of potash containing about 90 per cent. chloride of potassium, and some impurities consisting of chloride of sodium, sulphates of potash, soda, lime, and magnesia.

James Muspratt & Sons, Lancashire.

2680. Chlorate of Potash. Milk of lime of about 1·08 specific gravity, made by well stirring up about 18 ctr. slacked lime in about 6,800 litres water in a cast-iron vessel. The sample contains a small quantity of chlorate and of chloride of calcium from the previous solution made in the same vessel.

James Muspratt & Sons, Lancashire.

2681. Chlorate of Potash. Solution of chlorate of lime of about 1·15 specific gravity, containing at the same time chloride

of c[illegible] in the molecular proportion of about 1·5. Obtained by saturating milk of lime with chlorine gas. Towards the end of the process the temperature rises, when permanganate of lime is formed owing to the small quantity of manganese contained in the lime, by which the liquor obtains its pink colour. One litre contains from 45–48 grammes of chlorate of lime.

James Muspratt & Sons, Lancashire.

2682. Chlorate of Potash. Finished ground chlorate of potash, containing about 0·0[illegible] per cent. chloride of calcium, and about 0·125 per cent. moisture.

James Muspratt & Sons, Lancashire.

2683. Chlorate of Potash. First crystals of chlorate of potash, containing about 85 per cent. chlorate of potash, and 3-4 per cent. chloride of calcium.

James Muspratt & Sons, Lancashire.

2686. Chlorate of Potash. First mother liquor of chlorate of potash, of about 1·3 specific gravity. The solution of chlorate of lime is boiled down with a sufficient quantity of muriate of potash, and allowed to cool and crystallize for 8–10 days.

James Muspratt & Sons, Lancashire.

2684. Chlorate of Potash. Finished crystals of chlorate of potash, containing about 0·0502 per cent. chloride of calcium.

James Muspratt & Sons, Lancashire.

2685. Chlorate of Potash. Last mother liquor of chlorate of potash, of 1·35–1·40 specific gravity. The first mother liquor is boiled down still further, and allowed to cool and crystallize again for 8–10 days. It contains 30–40 grammes chlorate of potash, about 520 grammes chloride of calcium, and 3–5 chloride of potassium in the litre. *James Muspratt & Sons, Lancashire.*

2687. Caustic Soda Ash, containing about 12 per cent. caustic soda, 76–80 per cent. carbonate of soda, total strength about 54–56 per cent. Na^2O. Black ash is lixiviated in iron tanks, the liquor thus obtained is boiled down in open wrought-iron pans, and, as the crystals fall, they are fished out and calcined in an open furnace. *James Muspratt & Sons, Lancashire.*

2688. Nitre Cake, obtained in the manufacture of sulphuric acid by decomposing nitrate of soda with sulphuric acid. It is composed of sulphate of soda, together with small quantities of sulphate of iron, lime, and magnesia, of chloride of sodium, nitrate of soda, undecomposed nitrate of soda, and free sulphuric acid.

James Muspratt & Sons, Lancashire.

2689. Common Salt. From the salt works of Northwich, Cheshire, used in the manufacture of salt cake or sulphate of soda.

Sullivan & Co., Widnes, Lancashire.

2690. Salt Cake, or commercial sulphate of soda, containing about 98 per cent. of real sulphate, made by decomposing common salt with vitriol in an iron pan heated externally. When about three fourths of the decomposition has been effected, the charge is pushed upon the bed of a "muffle" furnace, maintained at a bright red heat till the decomposition is completed. The gaseous hydrochloric acid evolved during the process is conducted away through pipes or flues to condensing towers, where, being absorbed by water, it assumes the form of liquid acid.

Sullivan & Co., Lancashire.

2691. Limestone, or native carbonate of lime from Derbyshire, used in combination with slack or small coal for converting salt cake or sulphate of soda into carbonate of soda.

Sullivan & Co., Lancashire.

2692. Slack, or small coal from the Lancashire coalfield, used in combination with limestone for converting salt cake or sulphate of soda into carbonate of soda.

Sullivan & Co., Lancashire.

2693. Black Ash, or ball soda, containing about 24 per cent. of soda, produced by fluxing together in a suitable furnace a mixture of salt cake or sulphate of soda, limestone, and slack, by which means the sulphate of soda is converted into carbonate of soda, the carbonate of lime of the limestone into calcium sulphide, and the slack into coke. *Sullivan & Co., Lancashire.*

2694. Vat Liquor. A saturated solution of soda produced by lixiviating "black ash" or "ball soda" with warm water in iron tanks or vats; when the solution is saturated it is run off into iron pans to be boiled down, the calcium sulphide and unburnt coke of the "black ash" being left behind in the vat as "tank" or "vat waste." *Sullivan & Co., Lancashire.*

2695. Salts, or crude carbonate of soda, obtained by boiling down "vat liquors" in iron pans, heated either externally or by passing the flame over the surface of the liquor in the pan.

Sullivan & Co., Lancashire.

2696. Soda Ash, or finished carbonate of soda of commerce, containing 58·5 per cent. of real alkali, produced by gradually heating to redness in a reverberatory furnace "salts" or crude carbonate of soda. *Sullivan & Co., Lancashire.*

2697. Salt, as used in the "Hargreaves" process. The salt is placed in a moist state on drying floors, and when dried into hard flat pieces is broken by machinery.

Sullivan & Co., Lancashire.

2698. Salt Cake, or sulphate of soda containing 99 per cent. of real sulphate, made without the use of sulphuric acid by the "Hargreaves" direct action process. Salt maintained at a red heat in iron cylinders is exposed to the direct action of sulphurous acid, air, and steam. The hydrochloric acid from the salt is condensed as in the ordinary process.
Sullivan & Co., Lancashire.

2699. Native Peroxide of Manganese (Spanish), containing 80 per cent. of peroxide.
N. Mathieson & Co., Lancashire.

2700. Hydrochloric Acid, obtained by absorbing the gaseous acid in water. *N. Mathieson & Co., Lancashire.*

2701. Chloride of Manganese from native "manganese" stills *after* neutralisation with carbonate of lime.
N. Mathieson & Co., Lancashire.

2702. Limestone Dust. Crushed carbonate of lime.
N. Mathieson & Co., Lancashire.

2703. Manganese Mud, as precipitated *before* blowing with air. *N. Mathieson & Co., Lancashire.*

2704. Manganese Mud, *after* oxidation by blowing.
N. Mathieson & Co., Lancashire.

2705. Burnt Lime, from Buxton, Derbyshire. This lime is unslaked. *N. Mathieson & Co., Lancashire.*

2706. Hydrate of Lime, sifted and ready for the bleaching powder chambers. *N. Mathieson & Co., Lancashire.*

2707. Bleaching Powder, containing 38 per cent. of chlorine.
N. Mathieson & Co., Lancashire.

2708. Mother Liquor. When the crystallization of the soda is complete, the remaining liquid, or "mother liquor," is run off. This contains nearly all the soluble impurities in the "soda ash."
Gaskell, Deacon, & Co., Lancashire.

2709. Refined Alkali. To obtain this, soda ash is dissolved in hot water, the clear solution is evaporated, when a monohydrated carbonate of soda is precipitated, which is then calcined and ground. *Gaskell, Deacon, & Co., Lancashire.*

2710. Red Liquor. In some cases the vat liquor is not evaporated to dryness, the residual liquor (called, from its colour, "red liquor") containing the greater part of the caustic soda, sodium chloride, sulphate, sulphites, sulphide, and other impurities,

is separated, and subsequently treated for the production of caustic soda. *Gaskell, Deacon, & Co., Lancashire.*

2711. Oxidized Red Liquor. The sulphides, sulphites, &c. in the red liquor are wholly or partially oxidized by blowing air through the red liquor in deep iron vessels.
Gaskell, Deacon, & Co., Lancashire.

2712. Causticised Liquor. After oxidation the red liquor is diluted to about 1·080 specific gravity, and rendered caustic by agitation in contact with caustic lime.
Gaskell, Deacon, & Co., Lancashire.

2713. Cream Caustic. The causticised liquor is concentrated by evaporation until the solution sets hard on cooling, and tests 60 per cent. of alkali. During this concentration some of the sodium sulphate and a little carbonate are precipitated, and are ladled out, and any further oxidation required is effected by the addition of nitrate of soda.
Gaskell, Deacon, & Co., Lancashire.

2714. White 60 per cent. Caustic Soda. To obtain this the causticised liquor is concentrated until the unevaporated portion fuses, when the iron (which has probably been held in solution by combination with cyanogen), and the greater part of the alumina and silica, are precipitated and allowed to settle; the clear fused caustic soda, containing some sodium sulphate and chloride, is packed in iron drums.
Gaskell, Deacon, & Co., Lancashire.

2715. White 70 per cent. Caustic. This is obtained in the same manner as white 60 per cent., except that care is taken during the concentration to remove sufficient sodium sulphate and chloride to enable the resultant caustic to be of the required strength. *Gaskell, Deacon, & Co., Lancashire.*

2716. Chloride of Calcium. This is obtained as a bye product from the manufacture of bicarbonate of soda from the "Weldon" process. The solution of chloride of calcium is purified and settled, and concentrated by evaporation.
Gaskell, Deacon, & Co., Lancashire.

Composition:—

$CaCl_2$.
Aq.

2717. Soda Crystals, or **Washing Soda.** To obtain these crystals, soda ash is dissolved in hot water, and the clear solution

is run into iron vessels, where a large part of the soda crystallises out.

Gaskell, Deacon, & Co., Lancashire.

Composition :—

$Na_2CO_3 + 10$ Aq.

2718. No. 1. **Alkaline Silicate of Soda** (glass), suitable for soap making. *William Gossage & Sons, Lancashire.*

Composition :—

[illegible] O.
[illegible] O_2.

2719. No. 2. **Silicate of Soda** (glass), suitable for calico printing. *Willi[illegible] Gossage & Sons, Lancashire.*

Composition :—

100 parts [illegible]O.
310 „ [illegible]O_2.

2720. No. 3. **Silicate of Potash** (glass).

William Gossage & Sons, Lancashire.

Composition :—

100 parts, K_2O.
310 „ SiO_2.

2721. No. 4. **Solution** of **Alkaline Silicate** of **Soda,** made from No. 1. 1,500 specific gravity.

William Gossage & Sons, Lancashire.

2722. No. 5. **Solution** of **Silicate** of **Soda,** 1,375 specific gravity. Made from No. 2.

William Gossage & Sons, Lancashire.

2723. No. 6. **Solution** of **Silicate of Potash,** 1,350 specific gravity. Made from No. 3.

William Gossage & Sons, Lancashire.

2724. No. 1. **Cupreous Iron Pyrites,** employed in the manufacture of sulphuric acid.

Widnes Metal Company.

Water	·70
Sulphur	49·00
Arsenic	·47
Iron	43·55
Copper	3·20
Zinc	·85
Lead	·93
Lime	·10
Siliceous residue	·63
Oxygen, and traces of various metals	1·07
	100·00

15. No. 2. **Burnt Ore,** or cinder remaining after the complete elimination of the sulphur from the pyrites as rous anhydride. *Widnes Metal Company.*

Water	- - -	3·85
Sulphur	- - -	3·76
Arsenic	- - -	·25
Iron	- - -	58·25—83 per cent. Fe_2O_3.
Copper	- - -	4·14
Zinc	- - -	·37
Cobalt	- - -	traces
Silver	- - -	traces
Lead	- - -	1·14
Lime	- - -	·25
Oxygen and loss	- -	26·93
Insoluble residue	- -	1·06
		100·00

16. No. 3. **Mixture** of **Burnt Ore** and **Salt** (the latter about 12 per cent. of the whole), ground and passed through of about 16 holes per square inch.

Widnes Metal Company.

mixture is furnaced during a period of 5¾ hours, at the expiration of time the copper has usually been almost entirely converted into a chloride of that metal.

27. No. 4. **Mixture** of **Salt** and **Burnt Ore** after calcinauring 5¾ hours. *Widnes Metal Company.*

28. No. 5. **Purple Ore,** or residue left from No. 4 after xtraction of the copper by lixiviation with hot water and hydrochloric acid. *Widnes Metal Company.*

residue is chiefly employed for the "fettling" of puddling furnaces.

Ferric oxide	- -	96·20 = iron 67·35 per cent.
Lead	- - -	·86
Copper	- - -	·18
Cobalt	- - -	trace
Alumina	- - -	·45
Lime	- - -	·46
Soda	- - -	·10
Phosphoric anhydride	-	none
Arsenic	- - -	trace
Sulphuric anhydride	-	·49
Sulphur	- - -	·16
Chlorine	- - -	·03
Silica	- - -	1·22.
		100·15

29. No. 6. **Purple Ore** compressed into blocks for use in last furnaces (the brick exhibited was made by Messrs. N. ieson & Co., of Widnes). *Widnes Metal Company.*

...o. 7. **Solution of Copper** as drawn from the lixivia...ning, in addition to copper, &c., from three to four ...s of silver per gallon, with traces of gold.

A quantity of iodide of potassium (or zinc) sufficient to precipitate the silver present is added to this solution, and the precipitate formed is allowed to subside and collect, the supernatant liquor being passed into vessels in which the copper is precipitated by means of metallic iron.

ANALYSIS of COPPER S...TION of Sp. Gr. 1·24.

	Contents per gallon. Grains.
Sodium sulphate	10,092
Sodium chloride	4,474
Chlorine (combined with metals)	4,630
Copper	3,700
Zinc	480
Lead	40
Iron	32
Lime	52
Silver	3·06

Arsenic, antimony, bismuth, &c. not estimated.

Widnes Metal Company.

2731. No. 8. **Precipitate** caused by addition of a soluble iodide to solution of copper, &c. (Claudet's process), consisting of iodide of silver mixed with various salts of lead, chiefly sulphate.

Widnes Metal Company.

2732. No. 8A **Silver Precipitate,** obtained by the reduction of the iodide by means of metallic zinc.

Silver	5·05
Gold	·06
Lead	62 28
Copper	·60
Zinc oxide	15·46
Ferric "	1·50
Lime	1·10
Sulphuric anhydride	7·68
Insoluble residue	1·75
Oxygen and loss	3 62
	100,000

Widnes Metal Company.

2733. No. 8B. **Iodide of Zinc,** obtained by reduction of iodide of silver by metallic zinc, and used for the treatment of a further quantity of argentiferous copper solution.

Widnes Metal Company.

2734. No. 9. Copper Precipitate thrown down by the immersion of thin scrap iron in the cupreous solutions.
Widnes Metal Company.

(Contains on an average 75 to 80 per cent. of metallic copper.)

2735. No. 10. **Spent Liquor,** or liquid remaining after complete precipitation of copper from solution. This liquor is run to waste. *Widnes Metal Company.*

2736. Max Liebig's Apparatus for determining, for technical purposes, the quantity of oxygen and carbonic acid contained in various gaseous mixtures.
Joint Stock Company, "Rhenania," Stolberg, near Aix-la-Chapelle.

A description of this apparatus will be found in Ding. Polyt. Journ., Jan. 1873, of which copies may be had.

2737. Demby's Amylometer (potato-tester) accompanied by a description and case. *F. H. Büchler, Breslau.*

This instrument is quite new (1875). It is remarkable for its simplicity and accuracy, as well as for the rapidity with which the starchy matter in potatoes can be estimated. Rain water may be employed.

2738. Stammer's Testing Apparatus applicable to all the processes met with in distilleries, accompanied by a descriptive treatise. *F. H. Büchler, Breslau.*

This apparatus is quite new. It comprises absolutely true standard hydrometers for the determination of specific gravities, and replaces (for the most part) the purely empirical methods of testing which have hitherto been in use, by rational chemical methods.

2738a. Drawing of Root's Patent (special) Blower for Hargreaves' process in the manufacture of sulphates.
Thwaites & Carbutt, Bradford.

2738b. Model of Root's Patent Pressure Blower.
Thwaites & Carbutt, Bradford.

2738c. Artificial Fruit Essences, being solutions of various organic ethers in rect. spirit of wine. *Hirst, Brooke, and Hirst.*

They are nearly identical in flavour and chemical composition with the flavouring principles of the fruits they are intended to imitate:—

Jargonelle pear.	Raspberry.
Pine apple.	Greengage.
Apple.	Peach.
Strawberry.	Cherry.

f. Examples of Technological Diagrams.

Diagram 6. Retort for the manufacture of coal gas.
" 7. " " " "
" 28. Extraction of zinc (Silesian furnace).
" 31. Lime-kiln (continuous process).
" 32. Lead smelting (German cupellation hearth).
" 36. Lead smelting blast furnace.
" 37. Extraction of salt by evaporation of brine.
" 38. " " Graduation house.
" 50. Manuf[illegible]el evaporating pans by cementati[illegible]

The Council of the [illegible]ire College of Science, Leeds, Professor Thorpe.

2458. Gay Lussac's Apparatus for assaying Silver by the Wet Way. *Aug. Bel and Co.*

Copper cistern lined with resinous [illegible]nt to contain the normal solution of salt, 100 standard measures of which [illegible]espond with 896-thousandth of fine silver in the assay. Funnel for use in filling the cistern. Pipette of 100 cc, for use with normal solution. Pipette for use with decimal salt solution. Pipette for use with the decimal silver solution. Cage for conveying the bottles to the shaking apparatus. Shaking apparatus, filled with 10 assay bottles in position for use. Dark case for bottle, containing the decimal silver solution. Case in which the assay bottle is placed during the addition of the normal solution to the assay. Hollow pillar, with sponge for absorbing the excess of liquid from the front pipette during the adjustment of the level to gauge mark. Water bath used for heating assay bottles during the solution of assay pieces. Bellows used for removing the nitrous fumes from the assay bottles. Whisk used for stirring the salt solution in the cistern.

V.—APPARATUS ILLUSTRATING AGRICULTURAL CHEMISTRY.

2741. Specially made Balance, and other appliances, used in an investigation by Messrs. Lawes and Gilbert, to determine the amount of water given off by plants during their growth. See Journal of the Horticultural Society of London, vol. v., p. 38, 1850, and vol. vi., p. 227, 1851. The experiments were, however, continued to 1858, inclusive. *John Bennet Lawes.*

The balance, which was made by Mr. Oertling, of London, was constructed to turn with less than one grain, when loaded with 50 lbs., or even more, on each side. This it accomplished, but it was found that the quantity of water given off by the plants during their growth was so great that such accurate weighing was not necessary. In fact, during the whole period of growth, as much as from 15 to 20 lbs. of water was in some cases given off from a single jar of plants, and during the most active periods of growth as much as from 1,500 to 2,000 grains per day. In the earlier experiments the vessels in which the plants were grown were made of glass, but afterwards of zinc. There was no opening at the bottom for drainage. The top was closed by a glass plate, firmly cemented to the rim, but having a hole in the centre for the plants to grow through, and another smaller one nearer the side by which to

supply weighed quantities of water as needed, but which was, at other times, closed by a cork. To prevent, as far as possible, evaporation from the soil other than through the plant itself, small pieces of glass were laid over the centre hole, close up to the stems of the plants as they grew. Each jar held about 42 lbs. of soil. A standard leaden counterpoise was kept in the weight pan, and only the deviations above or below its weight were determined; a set of weights, from 10,000 grains down to one-tenth of a grain, being provided for the purpose. The weighings were generally taken at intervals of 10 days, but sometimes at shorter periods.

The list of plants experimented upon included wheat, barley, beans, peas, clover, mangold wurzel, turnips, and various evergreen and deciduous trees.

2742. Case of Casts of White Silesian Sugar-beet, illustrating the influence of different manures on the amount of produce, and on the per-centages of dry matter and of sugar in the roots. First season of the experiments, 1871. *John Bennet Lawes.*

2743. Also **Table of Average Results** obtained on growing the crop five years in succession on the same land. *John Bennet Lawes.*

Experiments conducted on the farm of John Bennet Lawes, Esq., Rothamsted, near St. Albans.

2744. Apparatus used in an investigation by Messrs. Lawes, Gilbert, and Pugh, to determine whether plants assimilate free or uncombined nitrogen; with drawings of some of the plants grown. See Philosophical Transactions, Part 2, p. 493, 1859; and Journal of the Chemical Society, new series, vol. i.; Entire Series, vol. xvi., 1863. *John Bennet Lawes.*

The tap being opened, and water allowed to flow from a raised reservoir into the large stoneware Woulfe's bottle, air passes from it by the small leaden exit tube, through two glass Woulfe's bottles containing sulphuric acid, then through the long tube filled with fragments of pumice saturated with sulphuric acid, and, lastly, through a Woulfe's bottle containing a saturated solution of ignited carbonate of soda; and, after being so washed, it enters the glass shade, from which it passes by an exit tube through an eight-bulbed apparatus containing sulphuric acid, by which communication with the unwashed external air is prevented. Entering with the shade at the side opposite to this exit tube is a tube for the supply of water or solutions to the soil, but which is at other times closed. In front of the shade is a bottle connected by a tube with the bottom of the earthenware lute-vessel, for the collection of the condensed water, which is from time to time withdrawn from the bottle by suction, and returned to the soil. The shade enclosing the pot and plant stands in the groove of a specially made, hard-baked, glazed, stoneware lute-vessel, mercury being the luting material. Carbonic acid is supplied as occasion may require, by adding a measured quantity of chlorhydric acid to the bottle containing fragments of marble, the evolved gas being, as will be seen, washed through one of the bottles of sulphuric acid, through the long tube, and through the carbonate of soda solution, before entering the shade. The short leaden pipe, bent and opening downwards externally to the large stoneware bottle, passes nearly to the bottom of it inside, and is a safety tube for the overflow of the water when the vessel is full, and so to prevent it passing into the wash bottles, &c. When full, the cork near the bottom of the stoneware vessel is withdrawn, and the water flows by means of a drain back into a tank, from which it is pumped into

59. Two Portfolios, containing diagrams referring to ınalysis, microscopical research, the laboratory fittings for ıtation, &c., at the experimental station.

Professor Dr. Leonard Roesler, Klosterneuburg.

60. Soil Thermometer of peculiar construction.

Professor Dr. Leonard Roesler, Klosterneuburg.

60a. Ebullioscope, for weighing alcohol in wines, Vidal's ı, improved. *M. Malligand fils, Paris.*

improved Ebullioscope of M. Malligand fils, is an instrument for ning easily and correctly, in a few moments, without distillling, and by ebullition, the quantity of alcohol contained in dry or sweet wines. w used by the Syndical Chamber of the Wine Trade of Paris, who und the Ebullioscope to be the most practical and most correct instru- all those used hitherto for ascertaining the alcoholic properties of (Sittings of 7th July and 6th October 1874.)
ıred by the Institute of France to be the best process known hitherto ghing alcohol in wines. (Report of the Academy of Science, vol. 80, Sittings of 3rd May 1875.)

VI.—METALLURGY.

61. Chart with **Photographs** of an **Assay-Balance** for **ns** of a **Weighing-out Assay-Balance** and of a **Blow- pparatus.** *C. Osterland, Freiberg, Saxony.*

balances represented by the photographs have the columnar lifting ıns constructed by the exhibitor, which not only allows of the beam aised from the outside, but which renders the displacement of so light ı impossible. Assay balances of this kind have been made by the ɔr, which weigh to the 20th or 40th of a milligramme.

62. Improved Furnace for Puddling Iron.

Jeremiah Head, M.I.C.E.

object is to utilize a portion of the waste heat which ordinarily is ged from the chimney, by causing it to heat air to be afterwards sup- r the combustion of the fuel. Part of the chimney is enlarged into a r, having a vertical partition extending nearly to the top. One half of mber thus divided contains a cast-iron stove pipe, and the other half is d with a damper.
ı the damper is withdrawn the heated products of combustion take rest route to the chimney, but when it is closed they are obliged to the more circuitous route, heating the stove pipe on the way.
ir for combustion is injected, by means of a steam jet, into a funnel ed with one side of a divided box, upon which the stove pipe stands. ed with the steam it becomes a powerful absorber and radiator of It passes through the heated stove pipe, and afterwards through the the furnace into a closed ash-pit, and a portion through tuyeres into e above the fuel.
s then attained a temperature of about 650 deg. Fahr. The con- n of coal of this furnace has averaged 12 cwt. 2 qrs. 11 lbs. per ton of

...rer two months of ordinary work, including lighting up and lost ...s about one half of the usual consumption of fuel. The iron ...d per ton of puddled bar in the same time averaged 20 cwt. ... lbs. The heating chamber is surmounted by a boiler, intended still further to utilise the waste heat. This, however, is not essential, and is hardly worth the extra expense. An ordinary iron-cased chimney is preferable.

2763. Models to illustrate Dr. C. William Siemens' processes for the production of wrought iron from iron ore, and of cast steel, in large quan...

No. 1. Regene... Furnace, from which wrought iron is obtained ... ...ed with fluxing and carbonaceous materials ... ...es. The puddled balls thus made may either be ... ...reated for the production of wrought iron, or be tr... ... steel melting furnace for the production of cast ste...

2. Regenerative Gas F... the production of cast steel in large quantities on ... ...earth, from pig iron, puddled blooms, iron or steel sc... ...ore.

2764. Improved Furnace for Puddling Iron.

Jeremiah Head, M.I.C.E., Middlesborough.

2764a. Whitwell's Fire-brick Hot Blast Stove or Oven, as specially designed for heating the blast for blast furnaces.

Thomas Whitwell, Stockton-on-Tees.

This model, to the scale of 1 inch to 1 foot, represents a stove 22 feet diameter × 28′ 6″ high, capable of heating 8,000 cubic feet of air per minute to a temperature of 1,400–1,450° Fah. during 60 consecutive minutes, after which it is again re-heated by the furnace gases, the combustion and absorption being so perfect that the products of combustion pass off to the chimney at a temperature of 250° Fah. only. These stoves are largely adapted to furnaces making Bessemer pig iron direct, also for anthracite fuel, and the various qualities of charcoal iron, Cleveland, spathic, spiegeleisen, &c.

The stoves are made of different dimensions to suit situation, but cost from 350*l.* upwards, according to size. Four stoves to the scale of the model make 500 tons a week of Bessemer iron with 19 cwt. of coke to the ton of iron. There is no loss of pressure by friction or loss of blast by leakage, and they require only two-thirds the quantity of gas that the ordinary cast-iron pipe system demands.

2764b. A Set of Drawings of two Blast Furnaces, erected at Middlesborough by Messrs. B. Samuelson and Co., together with the requisite heating stoves, kilns for calcining ironstone, blowing engines, &c. &c.

Bernhard Samuelson, M.P., Middlesborough.

The peculiarity is in the large dimensions of the blast furnaces (height from bottom of hearth to charging plate, 85 feet; diameter of box, 28 feet) resulting in a great economy of fuel; so that after they have been in blast nearly six years the quantity of coke required to produce a ton of No. 1 and foundry pig iron is on the average less than 22 cwt.

2765. Tubes tested with **Gunpowder,** to show the strength and ductility of Whitworth fluid compressed steel.

Sir Joseph Whitworth & Co., Limited.

These tubes were tested to ascertain the strength and ductility of fluid compressed steel, as made for guns, torpedoes, &c.

The ductility is shown by the metal belying under the strain, instead of flying in pieces.

2766. Sample Pieces of **Metal,** used for testing, to ascertain the strength and ductility of metal.

Sir Joseph Whitworth & Co., Limited.

There is no scientific line of demarcation between iron and steel. Sir Joseph Whitworth proposes that such a line should be established, and that the quality of a metal should be represented by two numbers, showing its strength and ductility.

These test pieces are similar to those in use by Sir Joseph Whitworth in testing his fluid compressed steel, to ascertain the proportions of strength and ductility which is required for different purposes.

The greater the strength, and the greater the ductility, the higher the quality of the metal.

2767. Sections of **Steel Ingots,** one cast in the ordinary way, the other compressed while in a fluid state.

Sir Joseph Whitworth & Co., Limited.

By the ordinary method of manufacture, it is found to be impossible to produce sound ductile steel suitable for constructive purposes, owing to the presence of honey-combed air-cells, which are altogether uncertain in their size and situation, and undiscoverable until laid bare by fracture or sections.

By compressing the metal while in a fluid state this defect is overcome, and a sound reliable material produced. This is shown by the two ingots, one cast in the ordinary way, and the other compressed while fluid.

2767a. Sample of Iron molten by means of compressed air.

Mr. Enfir fils, Paris.

2769. Set of cubical specimens of **Coal, Ironstone, Limestone,** and **Cold Blast Iron.** Illustrating the exact proportions, both in weight and bulk, of the minerals consumed in the blast furnaces for the production of cast iron at the Bowling Ironworks. *The Bowling Iron Company, Limited, Bradford.*

The coal is coked and the ironstone calcined preparatory to their introduction into the blast furnace.

2770. Case showing successive processes of Gold Assaying.

1. Tray on which assays are placed when ready for the furnace.
2. Muffle containing cupels.
3. Tray for annealing the buttons after being rolled or flatted.
4. Tray of platinum cups for "parting" the assays.
5. Platinum boiler in which the assays are treated with strong nitric acid.
6. Assay balance, capable of indicating the $\frac{1}{3000}$th of a grain when loaded with 7·5 grains.

ng so adjusted that sufficient silver is present to neutralize a given ' the solution employed as a precipitant. This solution is usually mmon salt, but hydrochloric acid or hydrobromic acid may some- used with advantage. The assay pieces, having been carefully re placed in numbered bottles, and a definite amount of moderately c acid is added to each, the bottles being then moderately heated to tion. The standard solution is then carefully introduced by means e, and the bottles are vigorously shaken until the precipitate coheres olution becomes clear. A cubic centimetre of "decimal" solution, $_{0}$th as strong as the "standard" solution, is then added to each they are again shaken. This is repeated until the decimal solution ither no cloud or a very slight one. This indicates the conclusion ation, as the amount of silver present can be calculated when the salt which is required to saturate it is known.

e above description it will be seen that the only special apparatus n assaying silver by the method of Gay Lussac is a pipette for out the "standard" solution, and one for adding "decimal" solu- d 2 are the forms of these used in the Royal Mint. The pipette rd solution, 1, is fixed in a vertical position and filled by an india- e from below. The opening at the upper end of the pipette is he finger, the india-rubber tube is removed, and the solution thus measured is added to the contents of a bottle. No. 2 is divided centimetres, and the additions made by means of it as already When great accuracy is required the decimal solution may be by drop by means of the apparatus No. 3, designed by Chevalier sdijk, of the Utrecht Mint.

. **Old Cupellation Furnace,** supposed to have been the by Sir Isaac Newton, when Master of the Mint, in some nts on the cupellation of silver. *The Master of the Mint.*

al construction it is precisely similar to those now in use, the only being that, in modern forms, more perfect means are adopted for the draught.

Touchstone for the Assay of Gold, formerly used yal Mint. *The Master of the Mint.*

hod is based on the fact that the greater the amount of gold con- an alloy, the brighter is the gold yellow colour of a streak drawn a black ground, and the less is it attacked by pure nitric acid or by cid. In ascertaining the richness of the alloy under examination is compared with marks drawn with alloys whose richness is known.

. **Diagram,** illustrative of a Westphalian blast furnace of nt construction, for the use of lecturers on metallurgy.
Professor Dr. Dürre, Aix-la-Chapelle.

. **Diagram,** illustrative of a lead smelting furnace on nciple, for the use of lecturers on metallurgy.
Professor Dr. Dürre, Aix-la-Chapelle.

iagrams are drawn to scale, and can also be employed for teaching re drawing and as designs for smelting works.

a. **Saturn Steel.** *M. Bréguet, Paris.*

VII.—MISCELLANEOUS.

2530. Phosphorus Eudiometer.
University of Munich, Professor von Jolly.

2531. Photograph of a **Wild's Polaristrobometer,** for determining the rotation at different temperatures. The tube containing the liquid is surrounded by a jacket, through which water of a given temperature flows. The apparatus is manufactured by Messrs. Hermann and Pfister, Bonn.
Professor H. Landolt, Aix-la-Chapelle.

2532. Photographs of a simple **Polaristrobometer** with two Nicol's prisms, constructed for holding tubes, one meter in length, containing the liquids which can be placed in a water-bath; and a blow-pipe lamp, over which is suspended a platinum gauze cage for holding the sodium salt which is used for producing the monochromatic sodium flame.
Professor H. Landolt, Aix-la-Chapelle.

The lamp is manufactured by Dr. Meyerstein of Göttingen, and by Feldhausen, philosophical instrument maker, Aix-la-Chapelle.

2533. Photograph of the same apparatus, provided with a short tube for holding the liquid. A bottle containing a solution of potassium dichromate is interposed between the tube and the sodium flame, to ensure a purer monochromatic light.
Professor H. Landolt, Aix-la-Chapelle.

2534. Apparatus for boiling off the air from sea-water.
Professor Oscar Jacobsen, Rostock.

2534a. Azotometer arranged for the easy and exact determination of the nitrogen contained in the manures employed in agriculture.
M. Houzeau, Paris.

2547a. Fairley's simple form of Ozone Generator in Glass.
Harvey, Reynolds, and Co.

2548. Smyth's Ozoneometer, for the observation of atmospheric ozone by means of an aspirator.
John Smyth.

This consists of two hard wood tubes or boxes, about two inches long and two inches in external diameter; the inner one is so much less than the outer as to fit tightly into it. It is also about one-eighth of an inch shorter, and its extremity at the open end is grooved for an india-rubber band, which holds the test paper stretched across its mouth. The entrance tube for the air

quarter of an inch in diameter, is fitted into the centre of the solid extremity of the larger or outer box about one-eighth of an inch from the centre of the test paper. A small pipe from the solid extremity of the smaller box communicates with the aspirator: Described at meeting of British Association for Advancement of Science, Birmingham, 1865.

2549. Drawings (4) of two apparatus for testing the **Products of the Perspiration of Animals;** the larger of this apparatus is destined for horses, cattle, swine, and sheep, &c.; the smaller serves for the same researches on poultry and rabbits, &c.
Professor Dr. Ignaz Moser, Vienna.

2550. Frerich's filtering Pump, made of platinum.
F. Sartorius, Göttingen.

2551. Frerich's filtering Apparatus, made of gutta percha. *F. Sartorius, Göttingen.*

2552. Frerich's filtering Apparatus, made of porcelain.
F. Sartorius, Göttingen.

2553. Frerich's Apparatus, for determining specific gravities in scientific investigations. *F. Sartorius, Göttingen.*

2554. A. Müller's Lixiviating Apparatus, provided with a set of sieves and a second indicator.
Franz Schmidt and Haensch, Berlin.

This apparatus is accompanied by a pamphlet descriptive of its application.

2556. Geissler's Apparatus for determining carbonic acid.
Ch. F. Geissler & Son, Berlin.

2557. Collection of Glass Stop-cocks of various sizes.
Ch. F. Geissler & Son, Berlin.

2558. Apparatus for producing a **Vacuum** for purposes of **Crystallization** and **Filtration.** *Hermann Fischer, Hanover.*

2559. Spring-Vacuometer, belonging to the above apparatus. *Hermann Fischer, Hanover.*

The apparatus, which is principally intended to replace Bunsen's filtering pumps, is constructed on the principle of the injection pump, producing a vacuum by means of a powerful jet of water. The little vacuometer contains a Schinz' tube. If the tube, marked water, be joined to the water supply pipe by means of an india-rubber tube, and the tube which in the drawing is not shown at all be joined to the waste pipe, and connexion be made with the vessel which is to be exhausted, a corresponding vacuum is readily produced. With a fall of water of 11 mm. a vacuum will be formed which at most will only fall short by one cm. from the absolute barometric height. If

...used be allowed to flow freely into a vessel, the level of the water ... deducted from the height of the water column above the appar... The vacuometer is made small in order to render the apparatus more handy. The apparatus may also be used without the vacuometer.

The advantages of the whole apparatus are as follows:—(1.) It is very handy; (2.) It may be used on every work-bench which is provided with a supply of water; and lastly (3.) It is very cheap.

2560. Apparatus for producing a Blast of Air by the fall of water. (Catal...

Dr. Otto Bach, Leipsig.

2561. Small ... Generator.

Julius Schober, Berlin.

2562. Hofmann's ... ensity Apparatus.

Julius Schober, Berlin.

2563. Hofmann's ... tand, the metal rings of which are lined with wooden rings ... g at an angle of 60°.

Julius Schober, Berlin.

2564. Knop's Improved Azotometer.

Franz Hugershoff, Leipzig.

2565. Wolf's improved **set of Sieves** with **Brushes.**

Franz Hugershoff, Leipzig.

2566. Winkler's Apparatus for gas analysis.

Franz Hugershoff, Leipzig.

One is intended for very small quantities of gases, carbonic acid, &c. Its advantage consists in the considerably narrowed part of the measuring tube above the lower three-way stop-cock, whereby finer divisions are rendered possible.

The other is constructed with a second three-way stop-cock, in the upper part of the measuring tube, which allows for the easy connexion with any other apparatus.

2566a. Drawing of Price's Patent Retort Furnace.

W. Price.

Description of Drawing.

Fig. 1.—Is a longitudinal section through centre of furnace.

Fig. 2.—A plan through the "retort," "combustion," and "heating" chambers.

Fig. 3.—A cross section through combustion chamber.

Fig. 4.—An elevation, part in section, of the retort chamber.

Fig. 5.—A sectional plan through retort chamber at E E.

Fig. 1.—A is a combustion chamber filled with grate bars in the ordinary way. B, a heating chamber, separated from A by the usual bridge. C, is the neck descending into an underground flue D, leading into an upcast or retort chamber, as it has been designated, E. In the centre of the chamber (E) is a firebrick circular pillar F, with spaces around marked in Fig. 5, E E E E, and on which is placed a cast-iron cylindrical air vessel G, which is protected by fire brick.

On this air vessel (G) is built a retort H, partly of fire-brick, partly of cast iron. The top of the cast-iron part of the retort is fitted with a hopper, I, in the throat of which is a damper, J, worked by a rocking shaft and lever, K, from the ground.

The lower portion of the retort made of fire-brick has two necks, L L, the one leading to the combustion chamber for the passage of fuel, the other to the outside of the furnace for the insertion of stoking tools, to force the fuel forward into the combustion chamber. The entrance of the outer neck is closed by an air-tight door M. The upcast or retort chamber (E) extends to near the top of the retort, where it is closed by brickwork, but is opened at the side by the flue N, leading to the stack O.

Near the bottom of the chamber E, and in a line with the centre of the circular air vessel G, are pipes P P, inserted in the walls of the chamber (E), passing all round the chamber as shown in Fig. 5. In front of the inner side of the circuit of pipes, and opening into the chamber E, are a number of port-holes Q Q Q (see Fig. 5), leading to the space around the pipes (P P), which space affords scope for expansion and a free circulation of heat. These pipes (P P) are connected with the blast as shown at E, Fig. 4, and pass into the central chamber G, as shown at F, Fig. 5, the outlet, R, from the air vessel leads into the ash-pit S.

The practice in working is to light a fire on the grate-bars, and generate heat in the usual manner, until the furnace is well heated. The retort is then filled with fuel, and the firing commences from the retort, and by the time the fuel at the top descends to the bottom of the retort, it is well heated, and a continuous supply of heated fuel is then kept up. All raw fuel is from this time supplied to the hopper (I) only, and let into the "retort" by the damper without the access of air.

The gases so generated in the combustion chamber (A) pass over the bridge into heating chamber (B), down the neck (C), into the underground flue (D), into the upcast or "retort" chamber (E), filling the spaces around, and giving up their heat to the circular air chamber (G), the retort (H), and the air pipes (P P), and their residue passing off by way of the flue (N) into the stack (O), the heat so stored being carried back into the furnace by the heated fuel. Combustion is supported by air under pressure from a fan. The air entering in as shown at (E), Fig. 4, traverses the entire circuit of pipes, passing into the central air-vessel (G), out through the outlet (R), into the ash-pit (S), and so up through the grate-bars.

2566b. Patent Platinum Apparatus.

Johnson, Matthey, and Co.

Newest form for the concentration of sulphuric acid, securing great strength, productive power, safety and economy in working, and highest degree of purity of acid, with a minimum of platinum :—

Boiler.—By the corrugated form of bottom (Prentice's patent) the greatest possible amount of strength, surface, and consequent evaporating power is obtained, and a considerable saving in fuel is effected.

Pans.—By means of these vessels the large and costly leaden tanks for the previous concentration of the chamber acid, which require constant repair and renewal and more or less contaminate the acid, are entirely done away with.

The setting of these boilers and open pans is of the simplest kind; they are placed upon an iron frame over a straight flue, and they may be multiplied or enlarged to any desired capacity of production, without sacrifice of existing plant.

Cooler.—An improved economical and convenient form, securing great cooling power with a minimum of water and space.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

rlohn gas lamp, middle size.
rlohn gas lamp, larger size.
fusion gas lamp, consisting of 11 single burners, and tand.
gas lamp, consisting of 3 burners, each possessing a gulator for a simultaneous supply of air and gas.
gas lamp, containing 4 burner tubes.

Julius Schober, Berlin.

Heating Apparatus for Laboratories.

M. Wiesnegg, Paris.

Arched Bunsen burner.
n Bunsen burner, with support.
isen burner of 8 millimetres.
ee tye-pieces for gas burners.
ble Bunsen burner.
snegg burner, with stand.
zélius burner, for gas and air.
ve "à couronne," No. 1.
Do. do. No. 2.
oratory blow-pipe, for petroleum.
lows, with handle and treddle.
lerc oven.
ës universal stand, with hook.
and blow-pipe.
nplete Schlœsing blow-pipe.
Schlœsing ovens, No. 1.
do. No. 2.
oven, and model of oven for melting platinum.
ot apparatus, No. 1.
ing framework of Perrot apparatus.
apparatus, No. 2.
coppel, No. 5, with treble clothing.
a retort.
te oxygen bladder.
rrot cocks and light strikers combined.
étuve."
" étuve."
g " étuve."
étuve."
irons for analysis (18 and 14 burners).
couronne," No. 1, for petroleum.
couronne," No. 2, for petroleum.
for incineration, with two jackets.
ra for lecture theatre.
till.
ner, No. (?), for petroleum.
s of various sorts, copper.
d gas caoutchouc.
snegg briquettes, No. 2, and 8 quarter briquettes.
snegg briquettes, No. 1 (?), and 8 quarter briquettes.
t plots.
meter glasses.
t mould and a large one.
and crucible tongs.

This ... ratus may be used for scientific as well as technical determinations ... carbonic acid contained in chalk, bone charcoal, &c., and is extensi...y used in the sugar refineries of Germany and Russia.

2598. Blowing Apparatus for working a blow-pipe.
C. Osterland, Freiberg, Saxony.

This blowing apparatus has two wind-chambers, whereby a perfectly regular stream of air may be obtained, even without any previous practice. It has a moveable jet, constructed by the exhibitor, with an air-tight ball-and-socket movement. It may ... t to a table, and will continue blowing for nearly a ... chambers get exhausted. It can also be worked by ... both hands free. The stream of air can be regulat... it every requirement.

2599. Copper ... ickel-plated, together with a tripod stand and rings ... well as metal, and provided with an arrangement for keepin... water at a constant level.
...runn, Quilitz, & Co., Berlin.

2600. Copper Water Bat... gether with a tripod stand, and an arrangement for keeping the ... at a constant level, a set of copper rings, and also a cover with different sized openings.
Warmbrunn, Quilitz, & Co., Berlin.

2601. Carmichael's Suction Funnel, with improvements.
Chemical Laboratory of the University of Göttingen (Professor Hübner).

2602. A. Mitscherlich's Apparatus for the continuous evolution of chlorine gas, together with a water bath having a constant water level. *Professor A. Mitscherlich, Münden.*

This apparatus is described in A. Mitcherlich's chemical publications, part 2, p. 6.

2603. E. Mitscherlich's Vapour Density Apparatus.
Professor A. Mitscherlich, Münden.

This apparatus is described in E. Mitscherlich's text book of chemistry, p. 308, and was employed by him in determining the specific gravity of vapours.

2604. Large Glass Gas Holder, described by R. Müncke in Dingler's Polyt. Journ., vol. 218, p. 40.
Warmbrunn, Quilitz, & Co., Berlin.

2605. Large Copper Gas Holder, of bright metal.
Warmbrunn, Quilitz, & Co., Berlin.

2606. Large Copper Gas Holder, bronzed, with top water-reservoir. *Warmbrunn, Quilitz, & Co., Berlin.*

2607. Müncke's Copper Water Oven, two-walled, with a Warmbrunn-Quilitz thermostat, a thermometer and side-tube, showing level of water. *Warmbrunn, Quilitz, & Co., Berlin.*

This apparatus is described in Dingler's Polyt. Journ., vol. 219, p. 72.

3. The same, made of **Zinc.**
Warmbrunn, Quilitz, & Co., Berlin.

). **Copper Drying-Closet,** single-walled, provided with ıbrunn-Quilitz thermostat and a thermometer.
Warmbrunn, Quilitz, & Co., Berlin.

). **Bunsen's Universal Clamp** and **Stand,** made of :kered, complete.
Warmbrunn, Quilitz, & Co., Berlin.

.. **Müncke's Large Universal Clamp** and **Stand,** rods made of brass, square foot-plate of iron and stands, e. *Warmbrunn, Quilitz, & Co., Berlin.*

cription of this apparatus will be found in Ber. d. Deutsch. chem. lin, 1873, p. 435.

!. **Müncke's Large Universal Stand,** with a large holder, round rods made of brass, and square iron foot- ›mplete (described as above).
Warmbrunn, Quilitz, & Co., Berlin.

!. **Stand** of iron, resting on an iron foot-plate, with three ed frames or ring-holders, vertical and horizontal ("Dop- en"), rings of three different sizes with straight rods for through the horizontal hole of the frame, binding screws,
Warmbrunn, Quilitz, & Co., Berlin.

ı. **Stand** made of brass, with iron foot-plate, five two-holed three large rings of different sizes, two clamps of varying made of brass.
Warmbrunn, Quilitz, & Co., Berlin.

). **Brass Stand,** on an iron tripod, with two simple brass holders. *Warmbrunn, Quilitz, & Co., Berlin.*

;. **Brass Stand,** on an iron tripod, with four brass holders. *Warmbrunn, Quilitz, & Co., Berlin.*

'. **Liebig's Condenser,** in **Glass,** supported by a brass ı an iron tripod.
Warmbrunn, Quilitz, & Co., Berlin.

!. **Bunsen Burners** (two), of simple construction.
Warmbrunn, Quilitz, & Co., Berlin.

). Same, with star, chimney, and reduction-cone.
Warmbrunn, Quilitz, & Co., Berlin.

). **Gas Lamps** (two), with arrangement for the simulta- ›gulation of gas and air, of simple construction.
Warmbrunn, Quilitz, & Co., Berlin.

rator, provided with a Geissler glass
Warmbrunn, Quilitz, & Co., Berlin.

without lip, 16 in the set, up to
Warmbrunn, Quilitz, & Co., Berlin.

ot lipped, No. $\frac{1-16}{1}$, $\frac{1-12}{1}$, $\frac{1-8}{1}$,

Warmbrunn, Quilitz, & Co., Berlin.

pped, No. $\frac{1-12}{1}$, $\frac{1-8}{1}$, $\frac{1-6}{1}$ set.
Warmbrunn, Quilitz, & Co., Berlin.

, 10 pieces, from 30 to 130 mm.
Warmbrunn, Quilitz, & Co., Berlin.

d (etched) **Reagent Bottles,** 27
Warmbrunn, Quilitz, & Co., Berlin.

d (etched) **Wash Bottles,** for

Warmbrunn, Quilitz, & Co., Berlin.

rs, of 1,000, 500, 250, and 100 cc.
Warmbrunn, Quilitz, & Co., Berlin.

of ¼, ½, and one litre.
Warmbrunn, Quilitz, & Co., Berlin.

urettes, four, of 20 cc. in tenths,
60 cc. in fifths.
Warmbrunn, Quilitz, & Co., Berlin.

tion Glasses for holding liquids,
Warmbrunn, Quilitz, & Co., Berlin.

olids, 1–8.
Warmbrunn, Quilitz, & Co., Berlin.

lasses, 11 pieces from 30–4,000 cc.
Warmbrunn, Quilitz, & Co., Berlin.

porating Dishes, lipped, 12 pieces,
Warmbrunn, Quilitz, & Co., Berlin.

asses, for evaporating, from 25–315
Warmbrunn, Quilitz, & Co., Berlin.

r, consisting of three equal-sized bell-
necks, holding about 2,000 cc.
Warmbrunn, Quilitz, & Co., Berlin.

2650. Drying Apparatus, with glass stop-cock.
Warmbrunn, Quilitz, & Co., Berlin.

2651. Exhaustion Apparatus, in glass, of two litres capacity.
Warmbrunn, Quilitz, & Co., Berlin.

2652. Bottle, for keeping mercury over acids.
Warmbrunn, Quilitz, & Co., Berlin.

2653. Levigation Apparatus, with four tubes.
Warmbrunn, Quilitz, & Co., Berlin.

2654. Air-pump Receiver, with tubulures and glass stop-cock, 280 mm. in height and 200 mm. in diam.
Warmbrunn, Quilitz, & Co., Berlin.

2655. Aspirator, consisting of a double tubulated Woulf's bottle and ground in glass stop-cock for the lower tube.
Warmbrunn, Quilitz, & Co., Berlin.

2656. Glass Stop-cock, 330 mm. in length.
Warmbrunn, Quilitz, & Co., Berlin.

2657. Vinegar Stop-cock, 190 mm.
Warmbrunn, Quilitz, & Co., Berlin.

2658. Glass Bow, for mercury, provided with glass stop-cock.
Warmbrunn, Quilitz, & Co., Berlin.

2659. Finkener's Gas Evolution Apparatus, quite new.
Warmbrunn, Quilitz, & Co., Berlin.

2660. Apparatus for the **determination** of **Water, Carbonic Acid,** &c., made by Dr. Geissler in Bonn.
Dr. Drevermann, Hoerde, Westphalia.

2661. A Collapsing Aspirator, of vulcanised rubber, for rapid gas-analysis. Arranged to measure the gas to be examined and to contain the absorbent. On agitation, the gas and absorbent are brought into contact. Used by H.M. Inspectors of Alkali Works. *Alfred E. Fletcher, Liverpool.*

2663. "Water Jet" Pneumatic Pump, for laboratories, &c.; designed by Professors Arzberger and Zulkowsky, and constructed by P. Böhone, Engineer, Brünn.
Professor Fred. Arzberger and Chas. Zulkowsky, of the Polytechnic Institute, Brünn, Austria.

The effect of this pump is based on the injection principle; it requires for working it a water supply conveyed by high pressure, but no fall below; hence the difficulties are avoided which frequently impeded the employment of earlier designed pneumatic water pumps. The rarefaction of air produced by it, which is entirely dependent on the amount of pressure caused by the influx of the water, may be increased with a single pressure of about one atmosphere to a degree of tension equal to that of steam.

Described in Liebig's Annalen der Chemie, Vol. 176.

ł. Description and drawing of an **Apparatus** for the **De-ation** of **Sulphur** (see the accompanying treatise: ·ismen über Steinkohlen von Dr. E. Muck.")

Berggewerkschaftskasse, Bochum, Rhenish Prussia.

ı. **Reich's Apparatus** for **estimating Sulphuric**

Royal Mining Academy, Freiberg, Saxony.

ı. **Winkler's Apparatus** for technico-chemical **Gas is.** *Royal Mining Academy, Freiberg, Saxony.*

. A **Soleil-Scheibler** improved **Polarising Appa-** or optical saccharometer) for determining sugars.

Dr. C. Scheibler, Berlin.

instruments exhibited by Dr. C. Scheibler are for the use of chemical es in beet-root sugar refineries. They are described in the "Journal Society for the Advancement of the Beet-root Sugar Industry of the ı Empire," edited by the exhibitor, and are used in the chemical of the society of which Dr. C. Scheibler is the director.

leil-Scheibler Polariscope, serves for the determination of the optical wer of sugar solutions, besides ascertaining quantitatively the amount gar contained therein. The improvements made by the exhibitor istrument (and described in the Zeitschrift for 1870, p. 609) are as –

ı the place of the two quartz-wedges sliding against one another in the struments, and which carry the scale and vernier, these instruments wedges so arranged that only one of them carrying the scale is the other bearing the vernier is fixed. By this means a much firmer the first wedge is secured, and the so-called dead-motion of the rew does not easily occur. In consequence of this the zero point of ges remains unaltered, which is a matter of considerable importance. ıe above-mentioned vernier resting on a firmly fixed quartz-wedge e within definite dimensions, by means of a key, without the position lge itself being changed. In this way an accurate adjustment to the : is easily accomplished.

ır the more convenient reading off of the experimental numbers a small round magnifying mirror is fixed above the scale.

› prevent any side rays interfering with the readings, all light is kept :ompletely light-tight sliding casing fitted over the observation tubes.

. **Mitscherlich's simple Polarising Apparatus** for ıgar refineries. *Dr. C. Scheibler, Berlin.*

. **Scheibler's Apparatus** for the **estimation** of **Car-** of **Lime** in bone charcoal, as well as for the quantitative :ic analysis of carbonates generally.

Dr. C. Scheibler, Berlin.

paratus was described by Scheibler in the above-mentioned Zeit- 1859, p. 285, and for 1861, p. 525.

. **Scheibler's Apparatus** for the **volumetric esti-** of **Carbonic Acid** contained in the gases of saturated

Dr. C. Scheibler, Berlin.

ed in Zeitschrift for 1866, p. 644.

... Scheibler's Apparatus for estimating the Refinery ... of raw Sugar. *Dr. C. Scheibler, Berlin.*

Described in Zeitschrift for 1872, p. 297, and 1873, p. 304.

2672. Stammer's Colorimeter for estimating the **Colour of Liquids.** *Dr. C. Scheibler, Berlin.*

2673. Hydrostatic Balance for estimating the **Density of Sugar** solutions and other l... *Dr. C. Scheibler, Berlin.*

Described in Zeitschrift for 18...

2674. Brix ... [illegible] ...arometer, consisting of three hydrometer tubes ... [illegible] ... packed in a case. *Dr. C. Scheibler, Berlin.*

2675. Gerlach's Stan... [illegible] ...ccharometer. *Dr. C. Scheibler, Berlin.*

2676. Scheibler's Muffle [illegible] ...atinum, together with platinum Scales and Stand used for the combustion of the ash in raw sugars. *Dr. C. Scheibler, Berlin.*

Described in Zeitschrift for 1867, p. 338.

2740. Chemical Apparatus, Photometrical and **Gasometrical Apparatus, Lamps, &c.,** invented by Professor Bunsen, of Heidelberg, and described by him in his "Gasometrical Methods" and other publications. *C. Desaga, Heidelberg.*

Spirometer.
Gasometer.
Galvanic battery, consisting of four elements.
Table blowpipe lamp, with 2 jets.
A 6-Bunsen burner blowpipe table lamp.
An 18-Bunsen burner blowpipe table lamp.
Oxy-hydrogen blowpipe.
Iron tripods, four different sizes.
Small tripods for fixing on lamps.
Small tripods for spreading out the flame.
Electrometer.
Bunsen's water vacuum pump.
A [illegible] plate.
Spark-producer.
2 compression clamps of different sizes.
Potash apparatus.
4 supports for flasks, &c.
Apparatus for cooling (condenser).
Bunsen gas burners, 18 different sorts.
Bunsen's lamps, five different kinds.
[illegible]'s lamp chimneys, 15 different sizes.
Lamps with double and treble air draught.

A 7-Bunsen burner lamp.
Sevenfold lamp.
Gas blowpipe, provided with stopcock.
Gas blowpipe, mounted.
Furnace, containing 25 burners.
Circular gas furnace, three different forms.
Absorptiometer.
Diffusion apparatus.
Dividing machine for glass gas apparatus.
Cathetometer.
Oxy-hydrogen generating apparatus.
Mercury trough.
System of convergent lines, etched on glass, for making divisions.
Hydrogen generating apparatus.
Apparatus for measuring the rapidity with which gases issue through a narrow aperture.
Spectroscope.
Spectroscope, provided with micrometer movement for the two telescopic tubes, an eccentric movement for the adjustment of the observation telescope, comparison prisms, cross-thread, &c.
Pocket spectroscope.
Universal clamp.
Stand for holding flasks, &c.
Stand for holding Geissler's tubes.
Stand for holding carbon points.
2 stands provided with adjusting screws.
2 stands provided with three legs.
3 holders for burettes.
6 rings of different sizes.
6 filtering rings of different sizes.
2 forks.
7 clamps.
Photometer.
Gas-clock.
Test-tube holder.
2 water baths, 2 sizes.
Apparatus for regulating the level of water.
Bunsen's gas regulator.
Drying apparatus.
Apparatus for showing the reversal of the sodium spectrum.
Several cases containing chemical substances for practising spectroscopic analysis.

SECTION 14.—METEOROLOGY.

WEST GALLERY, GROUND FLOOR, ROOM L.

I.—SPECIAL COLLECTIONS.

METEOROLOGICAL [illegible] SET AS LENT TO CAPTAINS OF MERC[illegible]OMPRISING :—

2776. Board of Tr[illegible]e Barometer, Kew pattern; the best barometer yet devised [illegible]se at sea, serviceable also as a station barometer; by Adie, marked B.T. 12; certificate of Kew verification in box.

2777. Board of Trade Ma[illegible]ne Thermometers. Set of six, Kew pattern; one for sea-water, in copper case, one for air, and one for evaporation temperatures, with three spare to replace breakages; by Casella, marked B.T. 1720 to 1725; certificate of Kew verifications in box.

2778. Board of Trade Thermometer Screen, for "dry-bulb" and "wet-bulb" thermometers, with water-cup. For use on ship board.

2779. Board of Trade Marine Hydrometers. Set of four; by Casella, marked B.T. 610, 620, 630; for testing the specific gravity of sea-water; by Hicks, A. 170, for the denser water of the Suez Canal; certificate of Kew verifications in box.

2780. Board of Trade Prismatic Azimuth Compass, in box; with spare compass card, in box; and tripod stand: by Barrow, marked B.T. 30. Tested and noted on the back of the cards at the Admiralty Compass Observatory. This instrument is lent only in a few special cases.

2781. Meteorological Register, for observers using the above instruments at sea.

2782. Rough Register, for use at sea. The observations should be entered at the time of making them, and afterwards copied into the preceding register.

Meteorological Committee of the Royal Society.

2783. Equipment of a Second Order Station, approved by the METEOROLOGICAL SOCIETY, consisting of the following instruments :—

STANDARD BAROMETER.

THERMOMETER STAND, containing DRY BULB THERMOMETER,

WET BULB THERMOMETER, MAXIMUM THERMOMETER, and MINIMUM THERMOMETER.

RAIN GAUGE.

BLACK and BRIGHT BULB THERMOMETER *in vacuo*, for determining the intensity of solar radiation.

MINIMUM THERMOMETER for determining the intensity of terrestrial radiation.

ANEMOMETER.

With specimen forms, instructions for taking, and tables for reducing the observations.

Publications of the Meteorological Society:
Reports of the Council, 1851 to 1861.
Proceedings, Vols. I. to V., 1861–1871.
Quarterly Journal, Vols. I. and II., 1872–1875.
List of Fellows, January 31st, 1876.
Catalogue of the Books in the Library, December 31st, 1875.
Instructions for the observation of phenological phenomena, charter, and byelaws. *Meteorological Society.*

2784. Instruments used at the Russian Meteorological Stations. A specimen set.

Wild's adjustable syphon barometer, No. 45, with screw for suspension and key for valve.
Three thermometers by Geisler, dry bulb and wet bulb, No. 244, minimum No. 138 ; in cylindrical paste-board cases.
Thermometer-screen, No. 141, made of zinc, to revolve round its vertical axis, carrying the above thermometers.
Saussure's hair hygrometer, No. 9, in box.
Russian rain and snow gauge, with glass measure, &c., No. 118.
Wild's anemometer of iron, for observing direction and pressure of wind. *Meteorological Committee of the Royal Society.*

2786. Meteorological Instruments, made under the direction of the late Sir John Leslie, and used by him.

Scottish Meteorological Society.

1. Portable Hygrometer (with specimen of Sir J. L.'s writing).
2. Stationary Hygrometer.

The covered ball in both cases being wetted and exposed to evaporation, the liquor soon marks, by its descent in the opposite stem, the dryness of the air.

3. Leslie's Atmometer. It consists of a ball of thin porous earthenware, to which is cemented a wide glass tube, bearing divisions which correspond each to the measure of a film of water that would cover the external surface to the thickness of the thousandth part of an inch.

1. Two volumes of the Society's Quarterly Reports from 1856 to 1863.
2. Vols. I., II., III., and IV. of the Society's Journal from 1863 to present date.
3. Three Papers by A. Buchan, Secretary, from Trans. Roy. Soc. Edin. *Scottish Meteorological Society.*

2787. Meteorological Instruments, set, for the use of colleges and public schools. *Francis Pastorelli.*

These instruments when compared with the standards at the Kew Observatory will be found to be within the error permitted by that institution.

They consist of a comparative standard barometer, maximum and minimum thermometer, wet and dry bulb hygrometer, terrestrial radiation thermometer, solar radiation (in vacuo) thermometer, rain gauge and graduated measure.

2788. Specimens of Meteorological Instruments, supplied by the Meteorological Office to the Royal Navy :—

Kew-pattern Marine Barometer, iron cistern, tube protected with India-rubber packing against damage by concussion from gun-firing, &c. ; by Adie, marked A 430 ; certificate of Kew verification in box. Glass tube and packing, as fitted to the above barometer.

Pair of Thermometers, maximum ↑ A 369, and minimum ↑ A 394 ; constructed specially for use at sea in chronometer rooms, by Hicks. Certificates of verification in box.

Aneroid, compensated for temperature, marked Elliott, A 421.

N.B. The thermometers, screen, and hydrometers supplied to Her Majesty's ships are of the same pattern as those lent to merchant ships and exhibited in case.

Portable Instruments used by Admiralty Surveyors : Pocket Aneroid, compensated, Casella, ↑ 6 (548).

Pocket Thermometer, mounted in boxwood, in leather case, Casella, No. 13.

Portable thermometer, in padded tin case, Hicks, B. T. 499; to give the temperature of the air by whirling around at the end of a string. *Meteorological Committee.*

2789. Specimens of Instruments used at Stations of the Meteorological Office :—

Barometer, used at Coast Stations as a weather-glass, by Hicks, M. O. 143.

Stevenson's Thermometer Screen, by Hicks.

Maximum Thermometer, by Negretti and Zambra, B. T. 215 (5577).

Minimum Ditto, B. T. 216 (10,435); certificates of verification in boxes.

Copper Rain, and Snow Gauge, Can, and Glass, by Casella, M. O. 150.

Solar Radiation Thermometer, in vacuo; Negretti's Maximum, with platinum points for testing, Hicks, M. O. 10.

Terrestrial Radiation Thermometer, hollow bulb for sensitiveness, Hicks, 18,429. *Meteorological Committee.*

2789a. Milne's Barograph, by West, clockwork, by Schoof. *Meteorological Office.*

2789b. Portable Barometer, graduated on the glass tube with a sliding vernier, invented and used by Sir John Richardson, M.D. *Meteorological Office.*

2789c. French Standard Barometer, by Tonnelot, J.G. 48, cistern of large diameter to diminish capacity error, with box. *Meteorological Office.*

2789d. Lamont's Atmometer. *Meteorological Office.*

2789e. Wall Screen, for registering thermometers. *Meteorological Office.*

2789f. Tube, Lath, and Thermometer, by Hicks, A 164, for taking earth temperatures. *Meteorological Office.*

2789g. Hypsometer Apparatus, as improved by Dr. G. Henderson, with two maximum thermometers, by Hicks, 39621, 39622, in leather sling-case, with certificates. *Meteorological Office.*

2789h. Johnson's Deep-sea Pressure Gauge, /\ 1, with box. *Meteorological Office.*

2789i. Deep-sea Thermometers:—

Johnson's metallic, /\ 6.

Negretti's protected bulb, /\ 9.

Casella's protected bulb, 21260, with certificate.

Elliott's unprotected, with certificate, /\ 36.

Pastorelli's unprotected, No. 5, out of order, used by Sir J. C. Ross. Notwithstanding the thickness of the glass a similar instrument to this rose 9·2°, under a pressure of two tons on the square inch. *Meteorological Office.*

2789k. Quarterly Journal of the Meteorological Society, Vols. I. and II., 1872 to 1875. *Meteorological Office.*

II.—BAROMETERS.

a. MERCURIAL.

2790. Large Standard Barometer, $\frac{7}{10}$ tube, with English and metrical scales, glass plunger cistern, and pipette in tube for preservation of vacuum. *Patrick Adie.*

2791. Medium Standard Barometer, $\frac{5}{10}$ tube, with glass ... for preservation of vacuum. ... observations. *Patrick Adie.*

2792. Small St... meter, with glass plunger cistern, and pipette i... vation of vacuum. Medical ... rtment, War Offic... *Patrick Adie.*

2793. Large Standard ... meter, with English and metrical scales, single read... w Observatory verification, and pipette in tube for preser... f vacuum. Kew pattern. *Patrick Adie.*

2794. Medium Standard Barometer, with English and metrical scales, single readings, Kew Observatory verification, and pipette in tube for preservation of vacuum. Kew pattern. *Patrick Adie.*

2795. Mountain Barometer, Fortin's, on tripod, with pipette in tube for preservation of vacuum. *Patrick Adie.*

2796. Gay-Lussac's Portable Barometer, with pipette in tube for preservation of vacuum. *Patrick Adie.*

2797. Mercurial Barometer, an old Dutch instrument by Reballio, combining syphon and long range barometer, thermometer, and hygrometer. *M. Pillischer.*

2798. Drawing of a "Balance" Barometer, of which a model was executed, submitted to the Royal Irish Academy, and tested during some months. *Jos. P. O'Reilly, Dublin.*

The column is inclined from the vertical, and suspended by a knife edge, as the beam of a balance, whence the proposed name. The displacement of the mercury in the column causes this to incline more or less from the vertical, the amplitude of movement showing itself on a graduated limb by means of an index. The mode of action and the degree of sensitiveness of the instrument are therefore comparable to those of a beam balance, and the indications given without the intervention of wheel work.

2799. Barometer of De Luc, formerly belonging to **H. B. de Saussure,** and carried with him in his Alpine excursions. *H. de Saussure, Geneva.*

2800. Meteorological Barometer by Wild, used in all meteorological stations throughout Russia.

Geneva Association for Constructing Scientific Instruments.

This barometer is a combination of Fortin's barometer, and of Gay-Lussac's old siphon barometer. For minute description, see "Mélanges physiques et chimiques, tirés du Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg," vol. ix, 23rd September to 5th October 1875.

2800a. Barometer of a New System of Construction.

W. Gloukhoff, St. Petersburg, Ministry of Finance.

For taking an observation with this barometer, the mercury of the cistern is forced to pass by means of the screw *A* through the hole *a* into the open space *s s*, formed by a glass ring, and to cover its bottom. Then the movable scale of the barometer is lowered so as to bring the steel end *C* of the scale near the surface of the mercury. Finally, by the screw *A* the surface of the mercury is made to touch the end *C* of the scale. The last part of the observation is made in the usual way.

2800b. Drawing of a **Normal Barometer** and **Manometer** of the Central Physical Laboratory, St. Petersburg, after the design of Wild, constructed by Brauer, St. Petersburg.

Dr. H. Wild, Director of Central Physical Observatory, St. Petersburg.

2800c. Drawing of a **Balance Barograph,** with temperature compensation according to a design by Wild, constructed by Hasler, Berne (Switzerland), registering by electricity every ten minutes.

Dr. H. Wild, Director of Central Physical Observatory, St. Petersburg.

2801. Stevenson's Portable Iron Barometer, with Mr. Sang's improvements. *Scottish Meteorological Society.*

All the stop-cocks being open, and the plug at lower limb out, fill in mercury till it begins to escape at this opening, shut stop-cock of lower limb, and fill to above upper stop-cock of upper limb; shut both stop-cocks of longer limb, put in the plug and open stop-cock at lower limb. The float should then show the true reading as compared with a standard instrument. In this way a reading can always be obtained at the most inaccessible stations as accurately as when the instrument left the maker's hand. Designed by T. Stevenson, C.E., F.R.S.E., Honorary Secretary, and described in the Society's Journal, Vol. iv, p. 265.

2801a. Capt. George's Improved Patent Mercurial Barometer for travelling. *Henry Porter.*

This process of filling by the spiral cord enables the traveller to fill the tube, and produce a perfect vacuum in about 15 minutes, and when the observation is registered the mercury is returned to its iron bottle and the *empty* tube returned to its packing of india-rubber and brass tube, so that it can be carried over the roughest country in perfect safety.

2[illegible] Mercurial Barometer; may be rendered entirely void of air in half an hour without boiling.

Professor Bohn, Aschaffenburg.

The instrument is easily constructed, even by persons without special training, at the place of observation itself. It is thus well adapted for transport. Permits controlling of the vacuum and avoids the errors of capillarity. No boiling of the mercury is required, and thus no loss of the graduated tubes is risked. The expense of executing the instrument is very small.

2803. [illegible] e bottom, Kupfer's method, improved b[illegible] Fuess, Berlin.

Imperi[illegible] raphical Bureau at Berlin, and [illegible] Hamburg.

Instruments of this kin[illegible] used as normal barometers in the meteorological system of t[illegible] tory.

2804. Glycerine B[illegible]

Jas. [illegible] rdan, Mining Record Office.

This instrument is desi[illegible] purpose of affording a delicate "weather glass," indicating [illegible] of pressure by large oscillations of a fluid column, at the same time preserving all the accuracy of the mercurial barometer. The fluid used is glycerine, in a maximum state of purity, which has a specific gravity of 1·26, or about one tenth that of mercury. It has the advantage of giving a vapour of very low tension in the Torricellian vacuum from its high boiling point, and is therefore free from the masking effect of back pressure which interferes with the indications of a water barometer. The fluctuations of the column are observed in a glass tube of 1 inch sectional area, or 100th that of the cistern. The tube forming the body of the instrument is an ordinary composition gas pipe, $\frac{1}{2}$ inches diameter, 27 feet long, placed in the well of the staircase, between the upper and lower galleries. The exposed surface of the glycerine in the cistern is protected by a layer of paraffin oil, in order to prevent absorption of moisture.

The divided scale on the right hand side is in inches and tenths in absolute measure, while that on the left shows the equivalent values reduced to a column of mercury

Instruments of this class can be constructed in the most simple form and at a moderate cost, and for museums and public institutions would be of great interest.

2805. Compensated Barometer.

Professor Dr. A. Kruezer.

The upper part of the tube is enlarged to a retort, the volume of which corresponds to a length of one or two metres of the tube. A quantity of air is introduced into the tube, the pressure of which is equal to about 34·5^{mm} mercury. The scale is divided with due regard to the effect of that depression. The zero having been adjusted by comparison with a standard barometer the reading will immediately give the barometer height reduced to normal temperature of mercury and scale. One millimetre of the scale $= \frac{1^{mm}}{\frac{P+p}{p}+\frac{345}{\lambda}}$, p being the area of the tube, P of the cistern, and $p.\lambda$ the volume of the upper part above 725·5^{mm} from the level in the cistern. An instrument of this construction has been in use some years at the Helsingfors Observatory.

2806. Standard Barometer, mounted in metal frame, with glass cistern, and pointed for adjusting the mercury before an observation is taken. *Elliott Brothers.*

2807. Diagonal Barometer invented by Sir Samuel Moreland, and made by T. Whitehurst, of Derby, 1772.
The Committee, Royal Museum, Salford.

The action of this form of barometer is explained in Rees' Cyclopedia, vol. 3., 1st edit., 1819.

2807a. Anerora or Mercurial Barometer, suitable for public buildings, at seaports, &c. Diameter of the dial, 1½ metre.
M. Redier, Paris.

2807b. Antique Baroscope. *G. J. Symons.*

2807c. Two Old Forms of Mountain Barometers.
G. J. Symons.

2808. Standard Metal Marine Barometer, Board of Trade pattern, as supplied to H.M. ships of war.
Francis Pastorelli.

The frame and cistern are of metal, bronzed, suspended by gymbals and a spring metal arm; it has a rotary motion to obtain the best light for observation. The barometer scale is divided to inches, tenths and 0·05 of an inch, the vernier, by means of a rack and pinion, works between two longitudinal openings; it reads direct to 0·002 of an inch, and by estimation to 0·001. The divided portion of the brass tube is protected from dust and moisture by a glass shield; the barometer tube is surrounded and packed by india-rubber to resist breakage by the discharge of heavy guns.

The barometer tube is made with a glass air-trap (a small portion of air ascending to the top of the tube would cause a great and variable error); this prevents the air from passing up to the top of the tube, which might occasionally happen with the barometer in careless usage. The interior diameter of the tube is about 0·35 of an inch. The mercury is carefully boiled in the tube to expel all particles of air and moisture. It is so contracted that an inch fall of mercury occupies four minutes of time; this is to prevent the oscillation of the mercury by the ship's motion. The scale divisions are corrected so that the error arising from the displacement of the zero by a rise or fall of the mercury in the cistern does not cause an error (in a well made barometer) of more than 0·008 of an inch.

2808a. Pastorelli's Mountain Barometer, in metal frame, similar in form to the Comparative Standard Barometer, specially designed for the use of civil engineers and scientific travellers.
F. Pastorelli.

Its great portability may be judged from the fact that its weight does not exceed 1½ lbs. Another very great advantage is that it cannot be deranged by careless use. The greatest error in this instrument rarely exceeds ·008 in. throughout its scale. It can be confidently recommended to engineers for a preliminary survey where greater accuracy is required than can be attained by use of the aneroid.

…ndard Barometer, upon Fortin's principle
Francis Pastorelli.

The barometer tube is enclosed in a brass frame; connected with the tube glass c… which is fixed by three pillars, the ends of which have …rs pass through an upper and lower brass plate, by means of which necessary pressure can be applied to make it mercury-tight, at the bottom of the cistern is a leather bag, which is raised or lowered by an adjusting screw, permitting the surface of the mercury to be brought into perfect contact with a piece of ivory which forms the zero of the scale; this point is seen through … The vernier works between two longitudinal … rack and pinion, so that it may be adjusted to … mercurial column, and it is divided to read to t… …ation to the ·001 of an inch; but in that case the use of a magni… microscope is indispensable. The thermometer has the divisions … the stem; it is fixed on the brass frame nearly in contact with the … The barometer is suspended from a bracket fixed to a m… …d, having a lower bracket with adjusting screws to fix it in a t… …al position. The instrument permits of a rotary motion, in order t… the best light for observation. The internal diameter of the tube of this b… …er is ·44 of an inch; the mercury is carefully boiled in the tube in ord… …sure the expulsion of all particles of air or moisture.

2809a. Carved Oak Barometer. *E. Cetti.*

2809b. Small Pocket Standard Barometer. *L. Casella.*

2809c. 1. **First Barometer,** with weights, by Conté. Used in the expedition of Egypt.
Conservatoire des Arts et Métiers, Paris.

2809d. Barometer, with overfall. Constructed by Mégné for Lavoisier. *Conservatoire des Arts et Métiers, Paris.*

2809e. Skeleton of Construction of the Largest Barometers for Public Buildings. (For demonstrating purposes.)
M. Richard, Paris.

2809f. Metal Barometer, of great sensitiveness (diameter, $0{\cdot}20^m$), of which the index describes a complete circle, under a differential pressure of one millimetre of mercury.
M. Richard, Paris.

2809g. Metal Barometer, for measuring heights (diameter, $0{\cdot}14^m$), of which the index describes a complete circle, by a difference of pressure of one centimetre of mercury.
M. Richard, Paris.

2809h. Aerostatic Barometer, with equal divisions, the index of which describes a complete circle, by a difference of pressure of one decimetre of mercury. *M. Richard, Paris.*

b. ANEROIDS.

2810. Aneroid Barometer. The ends of the axle which carries the index hand are jewelled like the pivots of a watch, and the hand works under the cap. By this means greater sensitiveness and especially greater definiteness of the indications are obtained. This aneroid will show a difference in height of 2 feet. *The Hon. Ralph Abercromby.*

2811. Aneroid Barometer, capable of measuring up to 5,000 metres from the level of the sea. With case, tables of comparisons, instructions, &c. *J. Goldschmid, Zürich.*

2812. Aneroid Barometer, capable of measuring from 9,000 to 10,000 metres from the sea level. With case, tables, and instructions, &c. *J. Goldschmid, Zürich.*

2813. Pocket Aneroid Barometer, of German silver. With case and instructions, &c. *J. Goldschmid, Zürich.*

2814. Aneroid Barometer, Weilenmann system. With tables. *J. Goldschmid, Zürich.*

2815. Aneroid Barometer, capable of measuring up to 5,000 metres. With tables, &c. *J. Goldschmid, Zürich.*

The faces of the above aneroid barometers are of German silver. The variations of reading are measured by a fine micrometer. A table, specially prepared, accompanies each instrument, and gives the height of the barometer. The correction for temperature, given in a second table, is founded on the observation of a small thermometer applied to the instrument.

2816. Miniature Aneroid Barometer, the dial measuring $\frac{3}{8}$ inch, the case $\frac{5}{8}$ inch in diameter, the bearings set in jewelled centres, compensated for temperature. *M. Pillischer.*

This is believed by the maker to be the smallest instrument of the kind ever constructed.

2817. Two Aneroid Barometers, *Reitz* system, with visible movement. *R. Deutschbein, Hamburg.*

2818. Two Metal Barometers, exhibitor's construction, with visible movement. *R. Deutschbein, Hamburg.*

2819. Two Spring Barometers, *Reitz* system, with visible movement. *R. Deutschbein, Hamburg.*

The first four pieces are house barometers, distinguished by good workmanship, shape, and cheapness. The last two instruments are spring barometers, specially adapted to meteorological observations, determination of heights, &c.

The aneroid barometers of the Reitz system are metal barometers with a vacuum box according to Vidi. The movements of the box are read off by means of a microscope on a scale which is divided into hundredths of milli-

Standard Thermometer, in maroon case.
L. Casella.

28 . **Maximum Thermometer.** *L. Casella.*
28. **Minimum Thermometer,** with forked bulb.
L. Casella.

2826j. Thermometer, 2 in. long, set in wood and zinc, divided into $\frac{1}{5}$°, for investigations of terrestrial heat.
W...bruun, Quilitz, & Co., Berlin.

2826k. Two Th - Maximum thermometers in case. *. Haak, Neuhaus, Thüringen.*

2826l. Two Th **om** Maximum on brass scale. *. Haak, Neuhaus, Thüringen.*

2826m. Continuous **istering Thermometer.**
W. Harrison Cripps, F.R.C.S.

The object of the instrument is to in a continuous registration of heat. The instrument is in two po the thermometer for indicating the temperature; 2ndly, the cloc registering the hours and minutes. The thermometer consists of glass tubing wound concentrically round an axis in such a manner as to form a spiral glass wheel 4 inches in diameter. The last coil is moved slightly away from the others, so that it shall form the circumference of a circle 5 inches in diameter. To each end of the axis a fine needle-pointed-pivot is attached. These pivots rest on minute depressions between two parallel metal uprights. By this arrangement the glass wheel can rotate freely between the uprights. The spirit in the thermometer fills the spiral portions of the tube, and also 3 or 4 inches of the last coil (the one forming the circle). The spirit then comes into contact with a column of mercury 4 inches in length. Beyond the mercury are a few drops of spirit to moisten the glass. The remaining portion of the tube is hermetically sealed, enclosing a small quantity of air. On the spirit expanding with heat, the column of mercury is driven forwards. This immediately alters the centre of gravity, and the wheel revolves in a direction contrary to that of the moving mercury. When the spirit contracts on cooling the enclosed air acting as an elastic spring keeps the mercury in contact with it, and the wheel regains its original position. By this arrangement the two forces, heat and gravity, acting in contrary directions, generate a steady rotary of motion.

The method by which this movement is made serviceable is by a grooved wheel 2 inches in diameter fixed to one of the pivots, and therefore revolving with the thermometer. Fixed to and passing over this wheel is a fine thread, from which is suspended a pencil holder, moving up and down on a vertical slide. The pencil will be raised or lowered according to the direction in which the wheel is moving. The other portions of the clock-work are arranged in a manner similar to that employed in the barograph.

In the present instrument a cylinder $4\frac{1}{2}$ inches, both in width and diameter, is made to revolve once in seven days. Around this cylinder is placed a paper, on which the days and hours are indicated by vertical lines. The cylinder is so placed that the surface of the paper is $\frac{1}{10}$th of an inch away from the pencil point, moving at right angles to its surface. A small striker is connected with the clock-work in such a manner that at every quarter of an hour it gives the pencil a tap, striking its point against the paper.

2826n. Fluctuation Thermometer. *Prof. Balfour Stewart.*

ıe scale for reading off the register is prepared by observing the extent to h the pencil rises for every 10°, as indicated by a standard thermometer. is particular instrument it is found that for every 10° the pencil is raised ın inch; this gives $\frac{1}{16}$ths for each degree, and the index is accordingly ed to this scale.

IV.—ANEMOMETERS.

328. Dynamic Anemometer for obtaining the horizontal vertical pressure of air in motion, upon inclined surfaces of rent forms and angles. Manufactured by John Browning he Society.

The Council of the Aeronautical Society of Great Britain.

ıis instrument is intended simultaneously to determine the component —*i.e.*, how much pressure is due to the horizontal, and how much to vertical—of a current of air when directed against planes of different , and of different forms, at angles varying from 15° to 90°. The experis are tabulated in the Aeronautical Society's Report for the year 1871 ıilton and Co.).

330. Static Anemometer, for measuring the force of the zontal component of the wind, especially of gusts.

Scottish Meteorological Society.

ro sets of Robinson's cup anemometers are placed one above the other on vertical spindle, so that the couple tending to turn the spindle depends ıe force of the horizontal component of the wind, not on its direction. ıe spindle is attached a spring, so that the magnitude of the couple (and fore the force of the horizontal component) is measured by the angle ıgh which the spindle is turned. This is recorded by a pencil which is l and lowered by a screw cut on the spindle. The clockwork and paper ecording have not been sent. Designed by Professor Crum Brown, , F.R.S.E., Member of Council.

331. Anemometer, for ascertaining pressure of wind.

Scottish Meteorological Society.

is anemometer acts by lengthening (not compressing). The maximum : is recorded by the thread which is fixed to the rod and pulled through le in the brass plate fixed to the side of the box. To ascertain the num elongation which takes place, press the thread against the plate, push in the disc until the part of the thread which has been drawn gh the hole is again tightened, and read off the result from the graduated The small disc is for high winds, the large for light. Designed by ıas Stevenson, C.E., F.R.S.E., Honorary Secretary, and described in ociety's Journal, vol. iv., p. 266.

332. R. Ballingall's Anemometer, for continually regisg the pressure of the wind. *Scottish Meteorological Society.*

e principle of this anemometer consists in a cistern of mercury in the and chamber, with a wooden plunger, which acts in connexion with the ıre plate. There is an arrangement by which the accuracy may be . at any time. Designed by the late R. Ballingall, and described at the al meeting of the Society, 2nd July 1874.

2834a. Anemometer, constructed by P. Schultze (Dorpat).
Prof. A. von Oettingen (Dorpat).

After 50 revolutions of the Robinson's cups an electrical contact is made, but only for a small fraction of a second, because after the movement of the differential wheel the electrical communication is broken, but at the same time prepared for the next operation.

2835. Anemometer (statical), in case.
Dr. G. Reckn[illegible]'s, K[illegible]tern (Physical Collection of the Royal [illegible]ol of [illegible]y).

The indications of the [illegible] [illegible]oportional to the pressure of the wind The small size of t[illegible] [illegible]d the ease with which its indications may be read off, [illegible] [illegible] advantageous for investigating ventilation The velocities of the first re[illegible]lution are marked on the outer scale, otherwise the constants are [illegible] with the apparatus. A small weight is added by way of a check; it [illegible]ances the spring suspended at a mark of the band.

2835a. Two Anemometers. *Dorton.*

2835b. Howlett's Anemometer. *Elliott Brothers.*

Consists of a copper sphere of such a diameter that the pressure of the wind on its hemisphere shall be equal to the whole or any required portion of a square foot; the sphere is mounted on a vertical rod that is suspended on knife edges like a balance, and registers the force and direction of the wind on a slate slab or on printed forms placed in the instrument for recording daily observations.

2836. Improved Anemometer of Combe.
Herm. Recke, Freiberg, Saxony.

All axle bearings in these anemometers are of stone. The setting and suspending is accomplished by pulling at one and the same knob. To facilitate the readings, dials with hands are provided. The fans are of trapezoidal shape and reach nearly down to the axle; they are of mica and capable of being proved, in order to allow of the finding of the most sensitive position.

2836a. Improved Anemometer of Combe.
Herm. Recke, Freiberg, Saxony.

In the preceding the axle of the fans remains unchanged during suspension inasmuch as only the dial work is moved; in this the axle is lifted parallel to itself.

2837. Pendulum Anemometer in a drawing, with explanation. *Professor Prestel, Emden.*

2838. Tangent Scale, for determining the mean direction of the wind. *Professor Prestel, Emden.*

2839. Balance Anemometer, constructed by Mr. Francis Ronalds at the Kew Observatory, in 1843, for the purpose of measuring the force of the wind.
Kew Committee of the Royal Society, Kew Observatory.

It consists of a light board, 1 foot square, fixed transversely to a cross of wood, suspended by a brass axis passing through its centre, and turning in

glass tubes in such a way that the cross can partially rotate in a vertical plane. The lower end of the bar carrying the board is counterpoised, so as to keep the surface of the board vertical, and a scale pan, hung to one end of the horizontal bar of the cross, serves to receive the weights, which are necessary to counterbalance the force of the wind, pressing on the board opposed to it, at any time. A small box, covering the scale pan, serves to shield it from the action of the wind. The instrument was, at the time of observation, placed so that the surface of the pressure plate should stand at right angles with the direction of the wind, as indicated by a vane.

2841a. Anemometer, large. *L. Casella.*

2842. Electrical Anemometer, by which the velocity of the wind in miles, &c., can be shown on dials in an observatory or study. *Yeates & Sons.*

2843. Robinson's Anemometer, for measuring the wind's velocity reading from $\frac{1}{10}$ up to 1,000 miles. *Francis Pastorelli.*

This instrument consists of four hemispherical cups fixed to four strong metal arms, that radiate from a central boss at a distance of 90° apart; at right angles to the plane of the cups is attached the vertical axis, its lower end terminates with an endless screw; this works two wheels which differ in the number of teeth, so that by their common revolution one has 100 times less velocity than the other.

The front wheel has two divided circles, the interior denoting 10 miles; each mile is figured and sub-divided into 10 parts; the outer circle is divided into 100 parts; each of these divisions represent 10 miles, every fifth division 50 miles, and they are numbered 50, 100, &c.; therefore readings from $\frac{1}{10}$ up to 1,000 miles can be taken by this instrument.

2844. F. Pastorelli's Electric Anemometer, to indicate from $\frac{1}{10}$ up to 10,000 miles. By the use of this instrument the velocity of the wind at any distant station may be seen by inspection in the observatory. *Francis Pastorelli.*

It consists: (1.) of Dr. Robinson's cup arrangement attached to a vertical axis; as it revolves the motion is conveyed by its endless screw to a wheel with a cam mounted in a rectangular metal box; here the angular velocity is reduced, so that each contact has the value of $\frac{1}{10}$ of a mile; (2.) the receiving instrument with its dial is mounted in a polished cabinet; it is worked by an electro-magnet and lever, so when the revolutions of the cups have indicated $\frac{1}{10}$ of a mile, the action of the lever works a wheel, and motion is communicated to a series. On the face of the instrument are divided circles and indexes which register from $\frac{1}{10}$ to to 10,000 miles of velocity. (3.) A Leclanché battery of four No. 2 cells is connected with the above, so that each $\frac{1}{10}$ of a mile, indicated by the revolutions of the cups, may be transmitted electrically and consecutively to the receiving instrument.

This instrument has the minimum amount of friction. The cup arrangement can be placed in any distant and convenient position, and the receiving instrument in the observatory. It is portable, being of small dimensions.

2845. New Portable Anemometer, by Francis Pastorelli, for measuring accurately the velocity of the air or wind, specially adapted for scientific travellers and explorers. *Francis Pastorelli.*

It consists of four small hollow hemispherical cups (Dr. Robinson's form) fixed to a vertical axis; the lower end has an endless screw. This works a wheel, the complete revolution of which is equal to $\frac{1}{10}$ of a mile. Its action is conveyed to others that carry indexes over divided circles on the face of the dial, which is mounted on a circular box fixed on a metal base; readings can be taken from $\frac{1}{100}$ up to 1,000 miles. Its weight, $1\frac{1}{2}$ lbs., and it packs in a mahogany case about $4\frac{1}{2}$ inches square.

This is a most sensitive instrument; its indications are as accurate as those of the large kind.

V.—RAIN GAUGES.

2847. Rain Gauge. In use at meteorological stations belonging to the Norway Meteorological Institute.

Professor H. Mohn, Christiania.

Square surface, 15 x 15 centimetres, height 50 centimetres, for catching snow; the lower part protected against evaporation. The rain (or melted snow) water is to be poured out of the gauge through one of its upper corners, into a measuring cylindrical glass, divided to show the height of fallen rain in millimetres. The gauge is made of plate iron, after design made by Professor H. Mohn. The measuring glass was calibrated at the Meteorological Institute, in Christiania.

2848. Rain Gauge, No. I. *Scottish Meteorological Society.*

Designed to obviate errors due to out-splashing and in-splashing of rain drops. Designed by Thomas Stevenson, C.E., F.R.S.E., Honorary Secretary, and described in the Edinburgh Philosophical Journal, 1842.

2849. Jagga's Rain Gauge, No. II.

Scottish Meteorological Society.

The principle of this gauge consists in making the diameter of the funnel equal to 4·697 inches, so that a fluid ounce of the rain-water collected equals one-tenth of an inch of rain. Designed by G. V. Jagga, Rao of Vizagapatam, and introduced to the Society by Sir Walter Elliot, Member of Council, and described in the Society's Report, quarter ending June 1861, p. 9.

2850. Ship Rain Gauge, No. III.

Scottish Meteorological Society.

This gauge is swung upon a horizontal swinging ring like a compass, which may be either fitted to a frame or suspended by a bracket. It is divided into two equal parts, fitting into each other about the middle of the instrument, which will always be maintained in the perpendicular position like a sea barometer. The advantages of this gauge are horizontality and saving of trouble in reading, and its principle consists in the use of cones to collect the rain. Designed by W. T. Black, Esq., Surgeon-Major, and described in the Society's Journal, vol. iii., p. 17.

2851. Ronalds' Rain and **Vapour Gauge,** erected at the Kew Observatory in 1843.

Kew Committee of the Royal Society, Kew Observatory.

An instrument constructed at the Kew Observatory, in 1843, by Mr. Francis Ronalds, for indicating a mean result from the quantity of water which may have fallen between any two given periods, *minus* the quantity of vapour which has evaporated in the same time, on and from a circular plane of one foot diameter. It is described in the British Association Report for 1844.

It consists of two cylindrical vessels, connected by a tube, the one being one foot in diameter, and open at the top, whilst the other is inches, and (with the exception of a small hole) entirely closed by a cover, which carries a frame, holding a circular divided arc, with an index moving over it. The index is attached to a small pulley, over which a cord passes, having its end fixed to the float in the cylinder. This, rising and falling with the changes of water level, indicates the amount of rain or evaporation on the metal scale.

2852. Glaisher's Rain Gauge. *Francis Pastorelli.*

This instrument has a greater internal depth, the coned part being 3 inches from the surface; in this respect it more resembles the Admiralty pattern; it prevents heavy rain splashing over, and consequent loss.

2852a. Mountain Rain Gauge. Capacity 48 inches. Pattern employed in the English lake district and at very wet mountain stations in Wales and Scotland. *G. J. Symons.*

2852b. Engineer's Rain Gauge. Capacity 12 inches. Adapted for rough observations in ordinary hilly districts. *G. J. Symons.*

2852c. Glaisher's 8-inch Rain Gauge. Adapted for and largely used by private observers. *G. J. Symons.*

2852d. Snowdon Pattern Rain Gauge, originally designed for use in North Wales, the deep cylinder being added to secure better observations during snow. This gauge is now in general use in all parts of the British Isles. *G. J. Symons.*

2852e. Indestructible Monthly Rain Gauge for private observers. *G. J. Symons.*

3852f. Copper Rain Gauge, Glaisher's form. *E. Cetti and Co.*

2852g. Electrical Self-registering Rain-gauge. *Yeates & Sons.*

The peculiarity of the above is a novel form of rocking bucket, the partition of which is so constructed that it will register correctly, no matter at what rate the rain may fall.

2852h. Self-registering Rain Gauge. *Elliott Brothers.*

This instrument consists of an upright square metal case, with funnel or receiver 10 inches square, with a set of counting wheels with dials registering from $\frac{1}{100}$ to 100 inches of rain fallen. The water falls into a trough with a division in the centre, having a motion on an axis, and being put at an angle, the rain overbalances it alternately, and is registered by the motion being communicated to the set of wheels, and consequently there is no evaporation to be deducted.

VI.—HYGROMETERS.

2853. Saussure's Hygrometer; an old specimen by V. F. Hausman. *G. J. Symons.*

2854. Whalebone Hygrometer, by Thos. Jones, of Oxendon Street. *G. J. Symons.*

2855. Daniell's [illegible]. No maker's name, but formerly belonging to [illegible]th. *G. J. Symons.*

2856. Balance Hygrome[illegible] drawing and essential part of the instrument). [illegible]*ofessor Buys-Ballot, Utrecht.*

At one arm of a balance is h[illegible] glass tube filled with chloride of calcium or any other hygros[illegible] substance. This tube is closed at its upper part by a cork stop, bearing two  bent glass tubes plunging in oil baths, but care is taken not to submerge their open ends. Two glass bells, ending in tubes at their upper parts and plunging for nearly half an inch in the same oil, render it possible to aspirate air through the chloride of calcium tube without affecting its movability. One of the bells is joined by an india-rubber tube with the spot the air of which is to be examined, the other with a gas meter and aspirator. In a given time you can in this manner weigh the water contained in a quantity of air indicated by the gas meter, and so conclude as to its humidity. It is obvious that the instrument can easily be made self-registering.

2857. A number of **Hygrometers** and **Psychrometers.** *Dr. H. Geissler, Bonn.*

2858. Klinkerfues' Bifilar Hygrometer, with reduction disc, executed by W. Lambrecht, Göttingen. *Professor Klinkerfues, Göttingen.*

The bifilar hygrometer shows the relative dampness without further reduction, upon a stereotyped scale of equal divisions, and also the dew point by means of the reduction disc.

The reduction discs for the psychrometer give likewise the dew point according to the following rule:—

The outer disc is turned round the inner one in such a manner that the two places of the evaporation temperatures, read off from the moist thermometer, coincide; with the place of the air temperatures upon the one will then also coincide the place of the dew point temperature upon the other. The one disc has yet a second division, which comes into use in the case of the evaporation temperature falling below zero.

The barometric pressure is assumed to be 750 mm.; for any other pressure b, the quantity $\frac{4}{375}$ (b – 750), taken in nearest round numbers, can be easily multiplied in the head by the thermometric difference, likewise taken in round numbers. The product expresses the number of hundredths of a degree, and has to be added to the air temperature, in order to obtain, after the setting of the disc, the dew point with greater precision. This correction is, however, seldom required in practice.

2859. Reduction Discs for Psychrometers. *Professor Klinkerfues, Göttingen.*

2861. **Psychrometer Scale,** for determining the relative and absolute moisture of the air, as well as the dew-point, without calculation. Model with explanation. *Professor Prestel, Emden.*

2862. **August-Psychrometer,** with two thermometers divided into $\frac{1^{\circ}}{10}$ on a stand. *Warmbrunn, Quilitz, & Co., Berlin.*

2863. **Catgut Hygrometer,** dating from the first quarter of the 18th century. Property of His Highness the Prince of Pless.
Sub-Committee of Breslau (Professor Poleck).

Interesting on account of its age.

2864. **Eight-Haired Saussure's Hygrometer,** by Richer of Paris, formerly the property of Mr. Francis Ronalds, and used by him at the Kew Observatory in 1843.
Kew Committee of the Royal Society, Kew Observatory.

2865. **Three Hair Hygrometers,** by H. B. de Saussure.
M. Henri de Saussure, Geneva.

Original models having belonged to himself, accompanied by tables drawn up by him and his son Theodore de Saussure.

2867. **Hair Hygrometer of De Saussure,** with two graduations, one being fractional of relative moisture.
Geneva Association for Constructing Scientific Instruments.

The faults found with the hair hygrometer are caused, generally, by the very great imperfection of the manufacture of those usually sold by the trade. The hair deteriorates, and from time to time its indications alter, because, as a rule, the weight of tension is too great. Hair properly prepared, and subject to due tension only, altered so little that M. Regnault tells of having found an old hygrometer made by Paul as correct as any modern instrument with which he has compared it. Another cause of irregularity proceeds from the careless choice of the hair. All hair that has been pulled about, and of which the limit of elasticity has been exceeded, should be avoided. The most isolated hamlets have now to be searched in order to obtain hair uncombed. The object of the Geneva Association for constructing Scientific Instruments is to rehabilitate the hygrometer of De Saussure by an improved construction. The general formation of the De Saussure hygrometer has been maintained as being the best, but the following modifications have been introduced:—

1st. The marking needles by the axle of the pulley are made of bronze aluminium, thus making the pulley lighter, consequently more moveable, and lessening the friction of the axle.

2nd. The weight of tension of the hair is replaced by a gold spiral, which makes the instrument more portable and avoids the twitching of the hair by oscillation and accidental displacement of the weight.

3rd. The hygrometer has two graduations (this is the chief modification); the first is an arbitrary division in equal parts of 0 to 100; the second marked out on a moveable arc, is superposed to the first and registers in hundredths the relative moisture, or the fraction of saturation. Thus, when the hygrometer registers 50, it is certain that the air

contains half the quantity of water that it can contain in the state of saturation.

The hygrometer is graduated according to "Regnault's" method.

2868. Hygrometer, modified by Dr. Geissler, with a delicate thermometer on a stand.

Will. Haak, Neuhaus am Rennweg, Thüringen.

2869. August's Psychrometer, on stand. The thermometer divided into tenths of [illegible] −30 to +45° C.

Will. [illegible] am Rennweg, Thüringen.

2870. Psychrometer, Augus[illegible]stem, with stand, in a case.

[illegible]. F. Geissler & Son, Berlin.

2870a. Psychrometer, August system, with stand, in a case, for travelling.

[illegible]. F. Geissler & Son, Berlin.

2871. Early Hygrometer.

Museum of King George III., King's College.

2871a. Oatbeard Hygrometer. *G. J. Symons.*

2871b. Old Travelling Hygrometer. *G. J. Symons.*

2871c. Modern Saussure's Hygrometer. *G. J. Symons.*

2871d. Mason's Hygrometer. *L. Casella.*

2871e. Pocket Hygrometer, in maroon case. *L. Casella.*

2871f. Dine's Hygrometer. *L. Casella.*

VII.—SELF-RECORDING INSTRUMENTS.

2872. Barometrograph, or Self-Recording Aneroid Barometer. *M. Pillischer.*

The construction of this instrument differs materially from others of a similar nature, by having the entire mechanism placed in a vertical line, whereby friction is reduced to a minimum.

The aneroid barometer, 18 inches in diameter, has two vacuum chambers; below it is placed the cylinder, carrying a ruled paper coinciding with the scale of the barometer, and driven by a powerful 8-day clock. The pencil point moves up and down upon a metal rod, prompted by the action of the barometer, and, by a simple mechanical arrangement connected with the clock, imprints the changes which occur from hour to hour on the ruled paper. Thus a black dotted undulated line is produced, showing the rise and fall of the barometer.

2873. Self-recording Barometer and Thermometer for use on board ships.

Dr. Franz Paugger, Director of the I. R. Commercial and Nautical Academy at Trieste.

This apparatus, which is enclosed in a small box, consists of three principal parts:

A thermometer, a barometer, and a contrivance for registering.

The thermometer is composed of a system of 10 zinc tubes, one foot English in length, which are placed side by side in the form of a cylinder, each one of which, commencing from the first, transmits, by means of a lever, to the next tube, in a somewhat augmented degree, its linear expansion produced by increase of heat. This system of tubes is suspended in the open air and surrounded by a shell or cover in the form of venetian blinds at the back of the parallel tubular box. From the end of the last tube a somewhat longer lever extends into the interior of the box, as far as the writing cylinder, by which the variation of the temperature, caused by the total expansion or contraction of the tubular system, is automatically recorded from time to time. The motor for the measurement of the atmospheric pressure is composed of 10 aneroid cases, which are joined together in the shape of a column. Their expansion or contraction, produced by the changes in the atmospheric pressure, is transmitted to the writing cylinder by means of a lever.

The arrangement for registering consists of a cylinder placed vertically, which is turned on its axis every 24 hours by a clock movement in the front part f the box. The two levers, both extending horizontally from the thermometer and the barometer, as far as the same edge of the cylinder, are at a mean temperature and a mean atmospheric pressure in a position the one in the centre of the lower, and the other in the centre of the upper half of the writing cylinder. Every 15 minutes, the ends of the levers, which are provided with pencils, are pressed against the cylinder, and by these means the variations of the atmospheric pressure and of the temperature are regularly registered. The instrument is in all its parts so contrived as not to require a fixed position, and being easily transportable, it can be used without difficulty on board ship.

2873a. Self-registering and Signalling Vessel Barometer. *Dr. Friedr. Müller, C.G., Osnabrück.*

This self-registering and signalling barometer is new, both as a whole, and in its details. The points of novelty are:

I. The bulb barometer, which is entirely independent of the registering and signalling mechanism, and which possesses the following properties:—(*a.*) The reading takes place at the *lower* level by unchanged position of the upper. (*b.*) The galvanoscopic adjustments, accomplished by means of the platinum point fused into the Torricellian vacuum, requires no sight, is very simple, quickly performed, and free from errors. (*c.*) The construction of the cistern with the barometric tube passing through it, whereby the level of mercury in the cistern is kept invariable. (*d.*) No boiling of the tube is required. (*e.*) By the introduction of a small quantity of dry hydrogen into the vacuum, the influences of temperature may easily be compensated.

II. The uninterrupted automatic adjustment, which makes all changes in the atmospheric pressure, even the smallest oscillations, *audible*. Specially deserving of attention are:—(*a.*) The two platinum points in connexion with (*b.*) the two sliding relays, working in opposite directions, and (*c.*) the two little electro-motor machines, which by their beats give direct indication of

all variations in the atmospheric pressure, and announce it indirectly by setting an electric clock-work into action. (*d.*) By connecting the two relays with the same point, the utmost sensitiveness of the automatic adjustment is reached, whilst the machines are in continuous action.

III. The registering mechanism, which is connected with the self-regulating barometer cistern, and moving in which the mercury in the barometer has no work to perform. Attention is called to the following points.—(*a.*) The force moving the marking pencil is a considerable one, in consequence of the multiplying gear; the wheels have to revolve 80 times in order that the cistern may move 1 m[illegible] stering mechanism allows, without losing anything of its [illegible] bility, a magnifying of the movement of the barometer [illegible] ement apparatus doubles the movement.) (*c.*) The instr[illegible] working for a month, and even longer, without interruption. [illegible] introduction of a new slip is easily accomplished in about one m[illegible] o new correction is then required. (*e.*) The second fixed pencil m[illegible] the margin of the paper slip a line, which by being broken every th[illegible] marks the time. This line serves also for adjusting, for the subseque[illegible] easuring of the curve and transparent scale, with the co-ordinate lines [illegible] ime and height.

IV. Finally, the mechanical execu[illegible] of the apparatus, which comes from the establishment of Herr *Wanke*, is d[illegible] ing of attention.

2874. Electric Registering Anemometer with momentary contact contrivance.

Professor Osnaghi, Imperial Meteorological Central Institute, Vienna.

The apparatus registers each kilometre by marks impressed on a slip of paper moved by clockwork.

2875. Wind-Current Autograph, or Registering Apparatus. *John G. Schoen.*

This "Wind-Current Autograph" marks, or registers, continuously and correctly, on a strip of paper moved by clockwork, the motion or direction of the currents of wind in such a manner that the time is indicated as the abscissa, and the angle of elongation of the weather-vane towards the north shown at every particular moment, as the ordinate.

2876. Electrical self-recording Anemometer and Printing Apparatus, invented by the Exhibitor.

J. E. H. Gordon, B.A., Cambridge.

The figures on the left hand side of the paper give the hours, those on the right the direction of the wind at each quarter of an hour, while for every mile of wind that passes over the cups on the roof a dot is made in the centre of the paper. The number of dots between any two consecutive figures is the velocity in miles per hour for that hour. The communication with the roof being made by electricity no shift is required.

2877. Automatic Light Registering Apparatus.

A. Salted paper.
B. Silver nitrate solution.
C. Trough for silvering paper.
D. Drying reel.
E. Dark box.
F. Insolator.

G. Cover for insolator.
H. Clock.
K. Battery.
L. Punch.

M. Reading-off apparatus :—

a. Drum.
b. Graduated strip.
c. Stand.
d. Sodium carbonate.
e. e. Platinum wires.
f. f. Stands for platinum wires.
g. Bunsen burner.
h. Lens.
k. Spirit lamp.

Professor H. E. Roscoe, F.R.S.

This method depends on the fact that the depth of colour produced on a properly prepared chloride of silver paper is directly proportional to the intensity of the light multiplied by the time of exposure.

The apparatus consists therefore essentially of two parts, one in which the prepared paper can be exposed for definite periods of time to the action of the light, and a second part in which the intensity of the tint obtained can be determined.

The paper (A), previously salted by immersion for five minutes in a 3 per cent. solution of sodium chloride, and cut into strips, is silvered by floating for two minutes in a 12 per cent. solution of silver nitrate (B), contained in the long trough (C), and afterwards dried on the reel (D).

The prepared paper may be preserved either before or after exposure in the dark box (E). It is next wound on to the bobbin of the insulator (F), which is placed in electric communication with the clock (H) by means of the battery (K); the free end of the paper, passing over the large wheel, being held in position by means of a small pin on the inside circumference of the wheel.

When a current of electricity passes, the magnet attracts the armature, and the wheel moves through a small space; the circuit is immediately broken and the armature released, and this slight movement of the wheel is repeated every time a current of electricity passes through the apparatus. The insulator is provided with a cover (G), in the top of which is a small circular hole, against which the prepared paper is pressed by means of a spring, and as the wheel revolves, fresh portions of the paper are successively brought under this hole, and thus exposed to the action of the light. The mechanism of the clock is so arranged that discs of prepared paper shall be exposed to the action of the light each hour for 10 different periods of time, which have been exactly determined, varying from 2 to 30 seconds, the object of this being to obtain, either with the feeble light of the morning, or the strong light of mid-day, a tint neither too light nor too dark to be read off. This is accomplished by means of a large metal disc in the clock, which revolves once in two minutes, and is in metallic connexion with one pole of the battery. On the face of the disc are placed 11 platinum pegs, arranged at equal distances from the centre of the disc, but at such different distances from one another that the first 10 intervals correspond as closely as possible to 2, 3, 4, 5, 7, 10, 12, 17, 20, 30 seconds respectively (their values being afterwards experimentally determined to one-fifth of a second), whilst the value of the last interval is of no importance. The other pole of the battery is connected with a metallic lever tipped with platinum, the insulator forming a part of the circuit.

Each hour this lever is lowered mechanically so that it comes in contact with the first platinum peg; the circuit is completed, the magnet in the insulator attracts the armature, causing the wheel to make a small fraction of a revolution, and a fresh surface of paper is exposed to the light. Contact is immediately broken, the peg passing away from under the lever, to be again

made when the next peg passes by, and so on through one revolution of the disc. After the 11th peg has passed by, the lever is automatically raised, and remains out of contact till the next hour. The last exposure, therefore, corresponds to the interval, the value of which has not been determined, this portion of the paper remaining exposed until the next hour.

After the apparatus has been in work for 24 hours the strip of paper is exhausted, and must be replaced by a new one.

On the paper thus exposed will be found repetitions of a series of 10 discs, of a tint which in each series gradually increases in intensity, separated by one black disc when the paper has been exposed for the whole hour One half of two or three of the discs in each series is cut away by the semi-circular punch (L), and the intens[illegible]e tint in each case read off. For this purpose the apparatus under [illegible] case (M) is employed. Round the drum (a) is pasted the gradu[illegible]ip (b), the intensity of the tint on any point on which may be found [illegible]ference to a table prepared for the purpose. The drum revolves fre[illegible] he stand (c). The paper to be examined is placed over the gra[illegible]ted strip, being held in position by the two clamps attached to the stand.

By means of the semi-circular hole, which has been punched into the exposed paper, the tint of the paper and of the graduated strip are brought side by side, and by revolving the drum with the hand various portions of the graduated strip are brought successively into juxtaposition with the tint of the exposed paper, and when the two tints are seen to be identical, the value of the exposed tint is known, corresponding of course to the one for that point on the graduated strip, and ascertained by reference to the table of intensities. A number of such readings for each tint are obtained and the mean taken as correct. These comparisons must be made by the light of the monochromatic soda flame.

Beads of sodium carbonate (d) on the platinum wires (e, $e_,$) are held by means of the stands (f, $f_,$) in the flame of the Bunsen burner (g), and the rays of light are concentrated on to the strip by the lens (h). When gas is not available the spirit lamp (k) is employed.

It now remains alone to divide the value of the tint thus obtained by the number of seconds which the tint has been exposed, to determine the intensity of the light for one second of time, which is the standard adopted. Two or three of the discs obtained each hour are thus read off, and the mean taken as representing the correct intensity.

2877a. Insulator and Whirling Apparatus.

Capt. Abney, R.E.

This instrument is based on the same principles as that of Professor Roscoe, but it was constructed with the idea that its portability may cause it to be employed in localities where his larger apparatus might be too bulky.

It consists of a revolving cylinder (round which is wound sensitive paper), driven by clockwork enclosed in a cover. In the cover is a narrow slit, extending across the cylinder, over which is pressed a black glass wedge of known graduation. The light falls through the wedge on to the paper in different gradations, according to the intensity of the light. The integration of the darking is obtained by placing the cylinder in a whirling machine, and the position of the standard tint is noted on a scale which depends on the graduation of the wedge. The total insolation is thus arrived at. When Professor Roscoe's and this instrument are worked together the results are accordant.

2879a. A full sized Lever Anemometer for self-registering the pressure of the wind.

C. O. F. Cator, M.A.

The pressure-plate is circular, has an area equal to 1 square foot, and is kept constantly face to wind by a vane (or by windmill fans); as it is driven forward by the wind, its motion is conveyed by means of a wire to a pencil, which continuously records every movement on paper revolving by clockwork below.

The peculiarity of this instrument is, that, instead of employing springs as the resisting medium, which from their proximity to the pressure plate and consequent continual exposure to the weather, cannot always preserve the same strength and elasticity, the resistance is furnished by a system of leverage. This consists of two eccentric curves of different sizes rigidly connected together and revolving on the same axle, of which the curvatures decrease respectively in opposite directions, so that the effect is doubled. Round the larger one a cord is carried, from which hangs a fixed weight. Round the smaller one a chain is passed, which is connected directly with the pressure plate, and also with the recording pencil. As the motion is direct, the spaces moved through by the pencil and by the pressure plate are exactly equal to another one and also to the primeter of the smaller curve.

One great advantage of this apparatus consists in its close proximity to the recording pencil, and in fact that the resistance is always the same, as every part of the instrument except the pressure plate is under cover and free from exposure to the weather. Another peculiarity of this instrument is that the plate is furnished with a conical back, so as to diminish the error arising from the formation of a partial vacuum behind it in strong winds.

The direction of the wind is also continuously recorded by Beckley's method, on the same paper as the pressure.

2880. Whewell's Anemometer. *Elliott Brothers.*

Consists of a delicate wheel with vanes and endless screw, working a series of cog wheels, which communicate with an ordinary lead pencil, that registers the force and direction of the wind on a vertical japanned cylinder. The cylinder is enclosed in a wooden case to prevent it from being injured by exposure to the weather.

2882. Registering Aneroid Barometer, for showing at a glance the various fluctuations that have taken place in the barometer. *Elliott Brothers.*

2883. Howlett's Portable Anemograph, an instrument which records the varying direction and force of the wind in the form of a map. *Elliott Brothers.*

2885. Self-recording Aneroid for Hall or Library; a graphic delineation of the change in pressure of the air for each week can be seen at a glance. *Francis Pastorelli.*

Fixed nearly in line, in a case, an aneroid, an eight day clock, and a revolving cylinder that occupies the central position; it is covered with metallic paper ruled for the days of one week, with the barometric scale in inches and tenths; upon this is marked every hour the pressure of the atmosphere; the markings have the appearance of a curved line, and the rise and fall of the barometer is seen at a glance for every hour of each day for one week, when a new paper has to be placed on the cylinder. The index hand on the dial

of the aneroid indicates the pressure of the air at the time of observation. Having already described the construction of the aneroid, it is only necessary to explain the method by which it is made self-registering. Connected with the lever that carries the chain round the arbour is a long watch chain that passes through the top of the aneroid over a pulley; it terminates with a metallic point, which is kept in working position by means of a vertical bar; this is capable of revolving upon its points. Behind the metallic point or pencil is the vertical revolving cylinder covered with the metallic paper; this is moved by the clock, which also presses the pencil point down upon the paper, and leaves a mark at each h[illegible]

2887. A Von [illegible] Self-recording Wind Components Integr[illegible] [illegible]ted by P. Schultze.

Dr. Arthur Von Oet[illegible], Professor at the Imperial University, Dorpat (Ru[illegible]ia).

The wind moves a system of hemispherical cups, like Robinson's, (which motion is replaced by clockwork for exhibition) acting on a circular plate, whose velocity is ordinarily proportional to the velocity of the wind. Four systems of sliding-rollers rest on this plate, whose bearings can be moved round a vertical axis, the principal planes of which imitate all variations of a wind vane. Each sliding roller can rotate about a horizontal axis, but only in one direction, and after a half rotation an electrical contact is made. A mechanism limits the contact to a fraction of a second. When the contact is made, one of four wheels, with number-types, is moved. Every half an hour the position of these four wheels is shown by printing numbers on a strip of paper. The differences of those readings represent the mean velocity of the wind from N., E., S., and W. They are converted into absolute values by means of a table. Different mechanism adjusts the portion of every sliding roller.

2888. A Complete Meteorograph.

F. Van Rysselberghe, Ostend.

Automatic Registering Apparatus.

2889. Photographic Proofs, obtained at various depths and at different seasons, to ascertain the penetration of the solar rays in the waters of the Lake of Geneva.

Professor Dr. F. A. Forel, Morges, Switzerland.

From these observations it has been found that the extreme limit of penetration at which the solar rays are capable of acting on chloride of silver is—

1. In the summer, when the water is, relatively speaking, not very clear, from 40 to 50 metres deep.
2. In winter, when the water is more liquid, 90 to 100 in depth.

To enable a comparison to be made with the clearness of the water in other lakes and in the ocean, and to give an idea of the degree of transparency of the waters of Lake Leman, it should be mentioned that on the 10th March 1875, at noon, the sun being at 39° 10′, a white plate or plaque 25 centimetres in diameter became invisible at a depth of 17·0 metres.

2890. Drawings of the principal parts of a meteorological registering apparatus, viz.:—

a. Scale-barometer, natural size.
b. Instrumental thermometer, natural size.
c. Air thermometer, natural size.
d. Clock-work and registering contrivances for only one of these instruments, since the mechanisms of all of them are identical; natural size. *Dr. P. Schreiber, Chemnitz.*

The apparatus represented in the drawings is intended for registering, at intervals of 10 minutes, atmospheric pressure, atmospheric temperature, and the temperature of the registering instrument itself. Only drawings could be sent in, as the construction of the apparatus is not yet finished. The instrument consists of four parts, viz., the barometer, the thermometer for measuring the temperature of the instrument, the thermometer for measuring the temperature of the air, and the propelling and registering mechanism.

The barometer is a balance-barometer of simple solid structure, with supporting pillar and beam of iron.

The thermometer for indicating the temperature of the instrument is a tube, closed at the top and open below, filled with air, dipping into mercury, and balanced by a weight on a string passing over a pulley. This tube moves 3 mm. for every degree C. of change in the temperature of the instrument.

The other thermometer, intended for the measuring of the atmospheric temperature, is likewise an air thermometer, consisting of a tube similar to the above described, but which contains an iron tube, joined to a narrow lead tube (2 to 3 mm. clear width), which again is connected with the thermometer bulb. This bulb is freely exposed to the atmosphere, though protected in a proper manner against rain and sunshine. It is made of copper, has a capacity of 5 litres, and a corresponding surface area. Here, too, a change of 1° C. gives a motion of 3 mm.

Let b, t, τ, signify pressure and temperature of the atmosphere and of the instrument, x, y, z, the respective positions of the tubes I., II., and III.; then $x=f_1\ (b, \tau)$, $y=f_2\ (b, \tau)$, $z=f_3\ (b, t, \tau)$, and hence $b=\phi_1\ (x, y)$, $\tau=\phi_2\ (x, y)$, $t=\phi_3\ (x, y, z)$, that is to say, the three quantities sought are determined by the positions of the three tubes.

The movements of the tubes are communicated to rods which move vertically in front of cylinders set revolving by means of a clockwork. This same clockwork moves also hammers, which hit every 10 minutes upon the rods, whereby marks are produced upon the cylinders, and thus the positions of the tubes noted. The clockwork is specially constructed for the instrument, and the largest toothed wheel, with 120 teeth, has a diameter of 120 mm.

Before each marking the tubes are slightly moved forward by steel cylinders which dip into the mercury. All movements are produced by a horizontal axis, which completes one revolution every 10 minutes, and which is provided with the necessary wheels, &c.

Electro-magnetism is used—

(1.) To mark the hours upon the cylinders.

(2.) To work signals, which will indicate a possible stoppage of the clockwork, or other interruptions in the working of the apparatus.

(3.) To sound, by means of the clock and a bell, the hours, thus giving evidence of the right condition of all the agents employed.

The advantages of the apparatus here described are:—

(1.) The constituent agents, the balance barometer, air thermometer, and registering clockwork, are all well tested instruments. The movements to be registered are so large that it is not necessary to magnify them. They can

be calculated beforehand by means of precise formulæ from constants that are easily determined with great exactness. The apparatus has, therefore, nothing of the nature of an interpolating instrument, a character belonging at present to all registering mechanisms, but must be viewed as a provision instrument. Checking observations, *daily* required by all self-registering instruments, become superfluous with this apparatus.

(2.) The registering instruments can be put up in a dry place, protected against changes of temperature.

(3.) All parts of the apparatus are of metal and glass, wood is excluded. The instrument is, therefore, more durable.

(4.) The construction is extremely simple; any disorder is easily repaired. The purely mechanical motors are free from the disturbances to which electro-magnetic motors are so frequently subject. If moderately well executed, and tolerably well handled, the instrument will, practically, never refuse to work.

(5.) The registering of the temperature of the instrument might prove useful in other observations, since it gives the temperature of a closed space.

(6.) Not the least of the advantages is the cheapness of the instrument.

The theory of this apparatus is given in full in Volume XI. of Carl's "Repertorium für Experimentalphysik."

2891. Kreils' Barograph, formerly in use at the Kew Observatory, for registering the movement of the barometer.

Kew Committee of the Royal Society, Kew Observatory.

An instrument employed at the Kew Observatory in 1845, for the purpose of registering automatically the height of the barometer. It consists of a syphon barometer, having a float resting upon the surface of the mercury, in the open end of the tube. Immediately above the tube a lever is fixed horizontally, and a cord, wrapped round a sector on the short arm, passes down and is attached to the float. The other end of the lever carries an ordinary pencil, which, being struck every five minutes by a hammer moved by a clock, makes a dot upon a sheet of paper fixed to a frame drawn in front of it by clockwork.

2892. Ronalds' Photo-Barometrograph, for registering photographically the changes in the height of the barometer, formerly erected at the Kew Observatory.

Kew Committee of the Royal Society, Kew Observatory.

An instrument for registering the variation in the height of the barometer upon a daguerreotype plate; constructed in 1847 by Mr. Francis Ronalds, afterwards erected at the Kew Observatory, and described by him in the British Association Report for 1851.

The light from an argand lamp, after passing through a condensing lens, falls on a narrow slit cut in a metal plate attached. A barometer tube, the mercury in which, by rising or falling, varies the length of the slit illuminated.

An achromatic combination of lenses, by Voigtlander, throws an image of the bright slit, magnified about 200 times, upon an aperture in the case, past which a daguerreotype plate is moved slowly by clockwork, and so registers the changes in the height of the barometer.

The barometer itself, together with its cistern, which is of large area, is suspended from an arrangement of levers and zinc rods, on the principle of the gridiron pendulum, in such a manner as to render the indications unaffected by fluctuations of temperature

An improved form of this instrument, in which the photographic image is impressed upon paper, is now in use at Kew, and at many other observatories.

2892a. Barometrograph. *M. Bréguet, Paris.*

2893. Barometer adapted to automatic registration by Photography. *Chas. Brooke, M.A., F.R.S.*

A vertical cylinder serves (as at Greenwich) for the registration of the barometer and the balanced magnetometer. *See* Magnetism.

2894. Barograph. *Redier, Paris.*

2895. Registering Barometer, mercurial or aneroid, showing enlarged curves without the aid of electricity or photography. *M. Redier.*

2895a. Registering Mercurial Thermometer, after the plan of M. Hervé Mangon. *M. Redier.*

2896. Barograph, balance barometer; executed by Greiner and Geissler, Joint Stock Company for manufacturing meteorological instruments at Berlin.
Imperial Admiralty Hydrographical Bureau at Berlin, and Deutsche Seewarte in Hamburg.

This instrument is put up and kept working at each of the normal observatory stations on the German coast. The stations are subordinate to the German Naval Observatory (Seewarte).

VIII.—EVAPORIMETERS.

2897. Evaporimeter, in the form of a spring steel-yard.
Professor F. Osnaghi, Meteorological Central Institute, Vienna.

This instrument shows on a sector the number of millimeters evaporated from a certain quantity of water in a given time. As its action is produced by gravity, it is also useful in winter when ice is formed on the scale. It differs from other steel-yards in the weight acting on the inner end of a spiral spring.

2898. Apparatus for determining the **Evaporation** from different soils.
Sydney B. J. Skertchly, F.G.S., H.M. Geological Survey.

The apparatus consists essentially of an evaporimeter composed of two vessels, the innermost of which receives the material to be experimented upon, and the external one supplies water to compensate for evaporation. Over this is a glass vessel which receives the vapour given off by the material. The temperature, &c., are registered by a hygrometer and barometer in the glass receiver, and the temperature of the soil by a ground thermometer. Any given temperature can be obtained by means of a platinum spiral heated by a galvanic battery. The evaporimeter maintains the material in a natural condition so far as regards temperature and moisture. Dry air is admitted into the glass receiver, and the air with the evaporated water passes from the top of the

receiver into a train of drying tubes; the current of air being produced by an aspirator containing oil. By means of this apparatus various soils, &c. can be brought under similar conditions of temperature, &c., and the evaporations compared for any temperature. The apparatus was especially designed to determine the proper amount of water which should be discharged by the artificial drainage system of the Fen Land.

2899. Integrator of Sun's Heat.

Scottish Meteorological Society.

When the water [illegible], some of it passes out at the bent upper tube. The l[illegible]t constant by a supply from the cistern which commu[illegible] by the india-rubber ball which acts as a valve.

Note.—The instrument, [illegible]ciple a weight thermometer, may also be used for ascertaini[illegible]perature of the air. Designed by Thomas Stevenson, C.E., [illegible]E[illegible]ary Secretary.

2900. Instrument, designe[illegible] ascertain the temperatures at which visible vapour is found. [illegible]ttish Meteorological Society.*

Water is heated in the main chamb[illegible]y a lamp beneath, and its temperature is read at the point when vapour [illegible]ears on one of the pieces of glass which are made to revolve slowly abov[illegible]e open end branch tube, and again read as the water cools, at the instant when condensation ceases to be observed. Designed by Thomas Stevenson, C.E., F.R.S.E., Honorary Secretary.

2901. Ebermayer's Evaporation Apparatus, for determining the degree of evaporation of different kinds of soil.

Professor Ebermayer, Aschaffenburg.

The evaporating apparatus and the earth thermometer are described at greater extent in "Die physikalischen Einwirkungen des Waldes auf Luft "und Boden," Von E. Ebermayer, Aschaffenburg, 1873.

2902. Morgenstern's Atmometer. *W. Apel, Göttingen.*

Morgenstern's atmometer differs from every other by its being founded on the principles of capillarity and of Mariotte's bottle.

The evaporating vessel is filled with siliceous sand, below which there may be placed a flat stone. This sand is saturated with water by capillarity; any loss of water by evaporation is at once replaced by a corresponding volume of water from a burette. This burette forms a Mariotte's bottle, the upper part of which is closed against the outer air by means of mercury. A tube, which dips into the sand and enters the burette from below, conducts air into the latter in proportion as water is lost through evaporation. When a large portion of the burette has become filled with air, the danger arises that the air column on expanding, by a possible rise of temperature, would exert a pressure upon the water below it in the burette, and thus lean to an over-saturation of the sand. To prevent this the small globular vessel is provided, which is also connected by a small tube with the burette, and into which the water, pushed on by the expansion of the air column, enters. With progressing evaporation this water returns again into the burette, or can later be drawn into the burette. This globular vessel is further intended for the filling of the burette with water, which purpose is accomplished by fixing an india-rubber tube, dipping into water to the open end, and sucking at the upper end of the pipette. Before the burette is completely filled the

india-rubber tube is removed, and the sucking at the upper end of the burette resumed, when, in consequence, the globular vessel is emptied. The connexion of the burette with the sand is closed during the operation of filling.

The evaporating vessel has a surface area of one square decimètre.

To exclude, as much as possible, the influence of the temperature, the evaporating vessel is enveloped in some bad conducting material.

The sensitiveness of the instrument is so great that a little dry sand, or a piece of blotting paper, or the fraction of a drop of water, put upon the surface of the evaporating vessel is immediately indicated by the water column in the burette.

2903. Atmometer or Evaporimeter, for determining the quantity of water evaporizing from the surfaces of waters as well as from different sorts of soil. *Professor Prestel, Emden.*

2904. Apparatus for the direct determination of the tension of aqueous vapour in the atmosphere, constructed in the year 1868 by Dr. Geissler, of Bonn, according to the instructions of the late Prof. Schulze, professor of chemistry in Rostock.

Professor Matthiessen, Rostock.

The U-shaped tubes serve for the reception of the mercury. The absolute vapour tension of the atmospheric air enclosed in the flask-shaped vessel is directly determined, at the differential barometer, through absorption of the vapour by concentrated sulphuric acid, which is introduced for that purpose.

IX.—OZONOMETERS.

2905. Ozonometer, for the determination of the amount of ozone in a measured volume of air by means of an aspirator, invented by the Contributor and described by him in a paper read at the meeting of the British Association in Birmingham in 1865.

John Smyth, Jr.

It consists of a box-wood tube or cylindrical box, about two inches long and two inches in diameter, one end of which is closed, except in the centre, where it is pierced by a quarter-inch tube communicating with the aspirator; the open end is covered by a lid or second box of the same material, which is so large as to slide over the first, and is also pierced by a quarter-inch tube, which, when the ozonometer is arranged for an experiment, directs the air against the centre of the test paper stretched across the open end of the inner or first box, and is secured there by an india-rubber band lying in a groove.

2905a. Schönbein's Ozonometer, rendered self-recording. An instrument for exposing each hour a fresh piece of Schönbein's ozone test-paper to the influence of the atmosphere.

R. C. Cann Lippincott.

Two cylinders (one large, the other small) are enclosed in boxes, the openings of which are guarded by india-rubber lips. The boxes are 2¼ inches apart. The large cylinder is moved round 2¼ inches each hour by means of a driving-shaft attached to the clock. A strip of test-paper, about 5 ft. long and ⅝ of an inch wide, is rolled round the small cylinder, the free end of it being fastened to the large cylinder; 2¼ inches of paper are thus exposed to the influence of the atmosphere.

The clock, which goes 8 days, indicates the minutes only, and shifts the paper by causing the large cylinder to rotate 2½ inches of its circumference exactly at the hour, thus removing the portion of paper (2½ inches long) exposed during the past hour, and exposing a fresh portion, to be in its turn removed at the end of another hour and succeeded by a new piece, and so on. At the end of 24 hours the whole strip of test-paper is unrolled by the observer from the large cylinder, dipped, and read by the scale (Schönbein's); a fresh strip is then rolled round the small cylinder, and its free end is attached to the large cylinder as before.

The instrument was made for me r. Casella, in 1868, after a plan of my own suggestion.

Most of this description is taken a letter to Mr. Glaisher, published in the "Proceedings of the Meteo cal Society," Vol. IV., p. 326. The results of some observations made with the instrument will be found in the "Proceedings of the Meteorological Society," Vol. V., p. 51.

2906. Aspirator, with gutta percha tubing and wooden box for tests, used by the Ozone Committee during their experiments in 1869. *Scottish Meteorological Society.*

The small tin box was made by a native Arab for Dr. Arthur Mitchell, in connexion with ozone experiments made by him in Algiers in 1855.

2907. First Ozone Generator. *Dr. Werner Siemens.*

The air or oxygen to be ozonised is caused to pass between two concentric cylinders coated with tinfoil, and electrified by an induction apparatus.

2907a. Tisley's Ozone Generator. The central tube being used as a water channel, a uniform low temperature can be maintained, thereby greatly improving the per-centage of ozone.

Tisley and Spiller.

X.—MISCELLANEOUS.

2909. Plan and View of the Observatory of the Imperial Central Institute for Meteorology and Terrestrial Magnetism, Vienna.

I. R. Central Institute for Meteorology and Terrestrial Magnetism, Vienna.

The building was erected, under the direction of the Imperial Minister of Education, by the architect Ferstel, and finished in April 1872. The Observatory is provided with a great number of self-registering instruments for all observations, among which may be particularly noticed Dr. Theorell's printing meteorograph for meteorological observations, and Adie's photographical magnetometer (Kew model), for the observation of magnetic variations.

2910. Meteorological Photographs, specimens as ordinarily produced at the Radcliffe Observatory, Oxford, containing the unreduced observations made with the barograph, thermograph, hygrograph, and anemograph, by the use of the waxed paper process, from November 19th to December 6th, 1873.

Rev. Robert Main, Oxford.

2911. The Storm Atlas of the Meteorological Institute of Norway, by H. Mohn. *Professor H. Mohn, Christiania.*

"Atlas des Tempêtes de l'Institut Météorologique de Norvége, publié avec " le concours de la Société scientifique de Christiania, par H. Mohn."

2911a. Goddard's Cloud Mirror. *G. J. Symons.*

2911b. Daily Bulletin of the Signal Service, U.S.A., May 1873. *J. Norman Lockyer, F.R.S.*

2911c. Atlas Météorologique de l'Observatoire de Paris, 1872–3–4. *J. Norman Lockyer, F.R.S.*

2912. Pane of Glass pierced by a **Hailstone** during the storm at Geneva in the night of the 7th and 8th July 1875. *Messrs. Ramboz and Schuchardt, Geneva.*

This pane formed part of the roof of the printing office, in a court of the Rue de la Pelisserie, at Geneva. No thunder-bolt fell in the neighbourhood, so that this strange oval opening, the upper edge of which, it may be noticed, is blunted, cannot be attributed to the action of lightning.

2812a. Large Globe in which H. B. de Saussure collected air on the summit of Mont Blanc. With portable case or shoulder basket, capable of holding two such globes. *M. H. de Saussure, Geneva.*

2913b. Dietheroscope. *Professor Luvini, through the Meteorological Office.*

2913c. Seven pictures of Clouds, according to Howard's nomenclature. *Meteorological Office.*

2913d. Meteorological Diagrams. *Meteorological Office.*

3 relating to storm of 12th March 1876.
8 individual storms.
1 list of stations.
2 wind diagrams.
6 Meldrum's theory of opposing air currents.
1 colliery explosions and weather.

2914. Map of Scotland, showing the Society's stations, the prevailing winds, and the annual rainfall. *Scottish Meteorological Society.*

The present stations are indicated by a *black* circle, and stations at which observations are no longer made by a *circle and a cross.* Rainfall stations by a *red* circle. Constructed by Alexander Buchan, M.A., F.R.S.E., Secretary.

2915. Temperature of the British Islands, for each month and for the year. *Scottish Meteorological Society.*

On all the maps the isothermals up to 44° are coloured *black;* those from 45° to 54° are coloured *blue;* and those from 55° and upwards are coloured *red.* Prepared by Alexander Buchan, F.R.S.E., Secretary, and published in the Society's Journal, vol. iii. p. 102.

2916. Seasonal Distribution of the Rainfall of Europe, showing the month of *greatest* rainfall and the month of *least* rainfall of its different regions. *Scottish Meteorological Society.*

The months from November to February are coloured *blue*; from March to May, *green*; from June to August, *red*; and September and October, *black*. Prepared by Alexander Buchan, Secretary.

2917. Charts, showing the mean monthly and annual amount of the diurnal oscillation of the barometer over the globe, from the a.m. maximum to the p.m. minim [illegible] by lines of 10, 20, 40, 60, 80, and 100 (and upwards) thous [illegible] hs of an inch (0·010, 0·020 inches, &c.). [illegible] ottish Meteorological Society.

The portions shaded *red* indicat [illegible] illation of 0·100 inch and upwards. Prepared by Alexander Bu [illegible] .R.S.E., Secretary of the Society, and published in Trans. Roy [illegible] ol. xxvii. p. 397.

2918. Charts, showing by is [illegible] ric lines the mean pressure of the atmosphere, and by *arrows* th [illegible] revailing winds over the globe for each month. [illegible] ottish Meteorological Society.

Isobarics of 30 inches and up [illegible] re coloured *red*, and those under 30 inches *blue*. Thus the red isob [illegible] dicate where pressure is in excess, and the blue isobarics where the pressure is in defect.

Calms are marked with a circle, and variable winds with an asterisk. The arrows fly with the wind.

Constructed by Alexander Buchan, F.R.S.E., and published in Trans. Roy. Soc. Edin., vol. xxv., p. 575.

2919. Diagrams, showing for London the influence of weather on mortality from different diseases and at different ages. No. I. *Scottish Meteorological Society.*

Mortality classed according to—

A. Age (average of 5 years).—Under 5 years coloured *red*; 5 to 40, *blue*; 40 and upwards, *black*.

B. Sex (average of 30 years).—Males coloured *red*; females, *blue*. The weekly deviations from the mean line are given in per-centages above and below the average.

C. Groups of diseases (average of 30 years).—The upper *thin* line represents weekly averages from all causes of death whatever; and the *thick black* line, from all causes minus violent deaths. The *red* space embraces deaths from all bowel complaints; and it will be observed that the subtraction of these diseases takes away the summer maximum from the general curve. The *blue* space embraces all diseases of the respiratory organs; and the *dark* space, diseases of the brain and consumption

The mean weekly temperature is represented by the *red* line.

Prepared by Alexander Buchan, Secretary, and Dr. Arthur Mitchell Chairman of the Medico-climatological Committee, and published in the Society's Journal, vol. iv., p. 187.

2920. Diagrams, showing the influence of weather on mortality from different diseases and at different ages. Nos. II. and III. *Scottish Meteorological Society.*

D. Showing mortality curves from special diseases, viz., small-pox, measles, whooping-cough, scarlet fever, typhus and typhoid fevers, erysipelas, metria, rheumatism, pleurisy, and pericarditis.

E. Showing mortality from bowel complaints, viz., dysentery, British cholera, cholera, and diarrhœa.

F. Mortality from diseases of the respiratory organs, viz., asthma, bronchitis, pneumonia, and laryngitis.

The curves under D, E, and F are the averages of 30 years, and the deviations from the mean lines are given in per-centages above and below the average.

Prepared by Alexander Buchan, Secretary, and Dr. Arthur Mitchell, Chairman of the Medico-climatological Committee, and published in the Society's Journal, vol. iv., p. 187.

2921. Diagrams, showing the mortality of British large towns. No. I. shows the weekly mortality from *all causes* for large towns of England, and No. II. for large towns in Scotland and Ireland. The averages are in most cases 10 years. The weekly averages are calculated at the annual rate of mortality per 1,000 of the population. *Scottish Meteorological Society.*

The mean annual mortality per 1,000 of the population of each town is given in the left-hand margin. The *red* lines show the deviations from this average for each week of the year.

No. III. shows the weekly mortality from *diarrhœa* for large towns of England, and for Edinburgh. The averages are in most cases for 10 years. The weekly averages are calculated at the annual rate of mortality per 1,000 of population. The breadth of space coloured red shows, for each week, the rate of fatality for each town.

Prepared by Alexander Buchan, Secretary, and published in the Society's Journal, vol. iv., p. 337.

2922. Diagram, showing the *steadiness* of the mortality curve of scarlet fever in each of the six epidemics which have occurred in London from 1840 to 1874. *Scottish Meteorological Society.*

A. represents the per-cent. of deviation from the mean line of each week's average of each of the six epidemics. The duration of each epidemic is given on the left-hand margin, and its average weekly death-rate on the right-hand margin.

B. shows the gross mortality for each year of the period, each epidemic being marked by a different colour.

By Arthur Mitchell, M.D., F.R.S.E., Chairman of the Medico-climatological Committee. Published in the Society's Journal, vol. iv., p. 340.

2923. Diagram, showing for London the relation of diarrhœa to temperature. *Scottish Meteorological Society.*

A. represents the mean temperature of 1859, having the hottest summer in London from 1845 to 1874; of 1860, having the coldest summer during the same period; and of 1861, having an average summer temperature.

B. represents the mean weekly death-rate in London from diarrhœa during each of these same years, the colours of the diarrhœa curves corresponding with those of the temperature curve for the same years. The weekly death-rate has been calculated in each case at the annual rate of 1,000 of the population.

By Arthur Mitchell, M.D., F.R.S.E., Chairman of the Medico-climatological Committee.

2924. Barometric Gradients.

Scottish Meteorological Society.

Model illustrative of the principle of the barometric gradient, which is calculated by dividing the distance between any two barometers by their difference in reading, both being reduced to 32° and sea level (or the same level). Designed by Thomas Stevenson, C E, Honorary Secretary, and described in the Society's Journal, 1867, when the proposal was first made.

2925. Drawing of an instrument for ascertaining sea and river temperature by thermometers continuously immersed.
Scottish Meteorological Society.

The case containing the instrume uspended from the pier, or lightship or in the river, and is drawn up bri ith it some water in the cistern at the bottom, in which the thermo bulbs are placed. Designed by Thomas Stevenson, C.E., F.R.S.E., orary Secretary, and described in the Society's Journal, vol. iv., p. 44.

2926. Cloud Reflectin spasses. For ascertaining direction of higher currents of
Scottish Meteorological Society.

When a cloud is to be observed the c pass should be turned round till one of the lines on the mirror coincides wi well defined edge of the cloud, and the compass is then made to revolve ually keeping the line constantly on the edge of the cloud. The angle ted by the magnetic needle being afterwards read off, the direction of the cloud's motion in azimuth is at once ascertained. Designed by Thomas Stevenson, C E., F.R S E, Honorary Secretary, and described in the Edinburgh Philosophical Journal, 1855.

2926a. Hypsometric Map of the Caucasus, recently published by the Topographical Office at Tiflis.
The Pulkowa Observatory.

2926b. Diagrams Illustrative of Underground Temperature. *G. J. Symons.*

2927. Graphic Representations of Underground Temperatures in Fifeshire, by Sir J. Leslie. *University of Edinburgh.*

2928. Graphic Representations of Underground Temperatures near Edinburgh, by Principal Forbes.
University of Edinburgh.

See Trans. Roy. Soc. Edin., 1846, for a full account of each.

2928a. Map of the **British Isles,** showing sites at which rainfall observations are being made. *G. J. Symons.*

2928b. Engravings of various apparatus employed in rainfall experiments. *G. J. Symons.*

2928d. Diagram showing the fluctuations of rainfall in central England, from 1726 to 1869. *G. J. Symons.*

2928e. British Rainfall. On the distribution of rain over the British Isles during the year 1874, as observed at about 1,700 stations in Great Britain and Ireland, with maps and illustrations.
G. J. Symons.

2928f. Monthly Meteorological Magazine.

2928g. Rain; How, When, Where, and Why it is measured? Being a popular account of rainfall investigations.
G. J. Symons.

2929. Meteorological Stand, with Psychrometer case, as used in the Imperial Navy. *C. Bamberg, Berlin.*

2930. Case for the exhibition of telegrams and weather reports of the Deutsche Seewarte (Nautical Observatory) at the signal stations on the German coast.
Imperial Admiralty Hydrographical Bureau at Berlin, and Deutsche Seewarte in Hamburg.

2931. Meteorological Window-stand, Reinert's system for the stations of the German Nautical Observatory (Seewarte).
Imperial Admiralty Hydrographical Bureau at Berlin, and Deutsche Seewarte in Hamburg.

The case contains a psychrometer and a thermograph (minimum and maximum thermometer); it is kept at a proper distance from the window, and when in this situation the sliding door is closed; on bringing it nearer to the window, for the purpose of reading off the indications, the door opens automatically.

2932. A Number of Weather Maps of the Deutsche Seewarte, for the month of March 1876.
Imperial Admiralty Hydrographical Bureau at Berlin, and Deutsche Seewarte in Hamburg.

2933. Storm Warner and Weather Indicator, original instrument, 0·85 in. long and 0·50 in. broad.

Annexed to the same is a treatise entitled: "Der Sturmwarner " und Wetteranzeiger, ein nach wissenschaftlichen Grundsätzen " ausgeführtes und durch Beobachtung und Erfahrung bewährtes " Instrument zur Vorherbestimmung von Sturm und Wetter."
Professor Prestel, Emden.

2934. Graphical Representation of the course of the weather in the years 1857, 1858, and 1859. *Professor Prestel, Emden.*

2935. Diagram of Solar Spots and their connexion with the variations of magnetic declination.
Professor Rod. Wolf, Zürich.

The upper black curve gives the monthly relative numbers, introduced by him, for the years 1831–1875; the red one their means from twelves to twelves. The lower black curve gives the corresponding yearly relative numbers for the years 1745–1875; the red curve their reduction to the scale of the variation of magnetic declination at Prague. To the last curve are added (in black colour) those obtained from observation of the variation of magnetic declination at Mannheim, Paris, London, Göttingen, and Prague, demonstrating the connexion between the frequency of the solar spots and the variation of magnetic declination.

29[illegible] [illegible]rtrede's Barometric Slide Rule, as arranged by M[illegible] [illegible]neral A. De Lisle, R.E., for barometric readings and b[illegible]g points. *Elliott Brothers.*

[illegible]he barometric scale is calculated from Bailey's formula. The range extends to about 15,000 feet of altitude, occupying the three faces of the slides. The back has logarithmic lines for computing the corrections, scales of which are given on the edges. The method of using the lines is given on the face of the rule. The corrections are: 1st, for temperature of mercury, 2nd, for temperature of air; and, 3rd, for latitude. Aneroids only require the two last. This rule was invented by the late Major-General Shortrede, formerly of the Great Trigonometrical Survey in I[illegible]

The logarithmic slide solves the [illegible] equations:—

$$x=ab\,;\ x=\frac{a}{b}\,;\ x[illegible]\,;\ x=\frac{c}{ab}$$

$$x=a^2\,;\ x=\frac{a^2}{c}\,;\ x=\frac{c}{a^2}$$

2938. Thermometer Screen f[illegible] meteorological stations of the 2nd order. In use at the stations [illegible] the Norway Meteorological Institute. *Pr[illegible]essor H. Mohn, Christiania.*

Made of plate iron. To be mounted ou[illegible]ide a window and kept in shade. The screen contains one psychrometer (d[illegible]y and wet bulb), one minimum thermometer (both instruments made by R. Grave in Stockholm), and one hair-hygrometer (made by Herman and Pfister in Bern). The screen is constructed after the designs of Professor H. Mohn.

2939. Thermometer Screen for one single thermometer for obtaining the temperature of the air. In use at stations belonging to the Norway Meteorological Institute.

Professor H. Mohn, Christiania.

Made of plate iron To be mounted outside a window or on a wall, and kept in shade With thermometer, made by R. Grave, in Stockholm. Screen constructed after the design of Professor H. Mohn.

2940. Thermometer Screen for one minimum thermometer. In use at stations belonging to the Norway Meteorological Institute. *Professor H. Mohn, Christiania.*

Made of plate iron, with double walls. Suspended on a cylindrical rod intended to pass through the window-frame. The rod has a handle inside, so that the screen with the thermometer can be turned for "setting" in the same way as a thermograph. The double walls prevent the rising of the thermometer, even in direct sunshine, to more than a few degrees above the temperature of the air. The minimum thermometer is made by R. Grave, in Stockholm. The screen is executed after designs of Prof. H. Mohn.

2941. Stevenson's Box for Thermometers.

Scottish Meteorological Society.

The box is louvre-boarded, and painted white inside and outside, and screwed to four stout posts, also painted white, firmly fixed in the ground. The posts must be of such a length that when the thermometers are hung in position the bulbs of the minimum thermometer, and of the dry and wet bulb thermometers, will be exactly at the same height of 4 feet above the ground, the maximum thermometer being hung immediately above the minimum

thermometer. The thermometer box is to be placed over a plot of grass, and in a free open space to which the sun's rays have free access during as much of the day as surrounding conditions enable the observer to secure. The thermometers are suspended on cross-laths in the centre of the box, and face the door, which should open to the north.

Designed by Thomas Stevenson, C.E., F.R.S.E., Honorary Secretary, and described in the Society's Journal, vol. i., p. 122.

2942. Apparatus, by "Baudin," for observations at sea, with maxima air-bubble thermometer of "Walferden," and minima vertical thermometer of "Baudin," withdrawn from external pressure. *M. Baudin, Paris.*

2942a. Model, illustrative of Meteorological Sections of the atmosphere. *Scottish Meteorological Society, Edinburgh.*

Showing vertical gradient for temperature, pressure, humidity, &c., ascertained by dividing the difference of readings between the instruments at the two heights by the height between them. Designed by Thomas Stevenson, C.E., F.R.S.E., Honorary Secretary, described at a general meeting of the Society, and published in "Nature."

SECTION 15.—GEOGRAPHY.

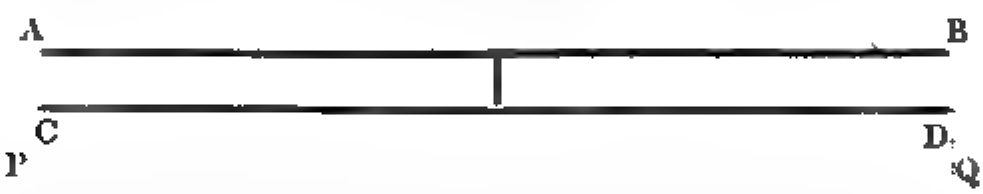
WEST GALLERY.—ROOMS L. AND M.

I.—SURVEYING INSTRUMENTS.

COLLECTION OF INSTRUMENTS LENT BY THE ORDNANCE SURVEY.—MAJOR-GENERAL CAMERON, R.E., C.B., F.R.S., DIRECTOR-GENERAL.

2943. Colby's Compensation Bars.

The first operation in an extensive survey, viz., the measurement of a base line, is beset with many difficulties, one of the greatest of which arises from the fact that the lengths of the measuring rods, bars, or chains vary with the temperature. This could be got over if one could ascertain at any moment the precise temperature of the rods, bars, or chains, but it is not easy to be assured on this point. Hence arose the idea of a compensation apparatus, which was carried out by Major-General Colby, at the commencement of the survey of Ireland, in the following manner. Two bars of different metals and different rates of expansion are laid parallel and close to each other as AB, CD—



They are firmly connected at the centre, from or to which point they are free to expand or contract. At a given temperature they are taken of the same length, and in this state suppose lines ACP BDQ to be drawn through their extremities, so that AP—BQ make also the ratio of AP to CP and of BQ to DQ, equal to the ratio of the expansion of the bar AB to that of the bar CD. Now, if we suppose both bars to receive an equal increment of temperature, and in this position lines to be drawn through their extremities, these lines will pass through the points PQ.

The compensation bar, then, consists of a bar AB of brass, united at its middle to an equal bar CD of iron; at each extremity of the bars is a metal tongue, connected with them by pivots. These pieces are about six inches in length, and on a silver pier at the extremity of each is a finely engraved dot. The dots are 10 feet apart at all temperatures.

When used in measurement of a line, the dots on two adjacent bars are brought to the precise distance of six inches apart by means of a compensation microscope. The compensation microscope is formed by uniting two ordinary microscopes by parallel bars of iron and brass, in such a manner that their outer foci are "compensated," and measure six inches whatever may be the temperature. The whole apparatus consists of six bars and seven microscopes, of which two bars and three microscopes are now exhibited.

Two base lines have been measured with this apparatus, one in the north of Ireland, in 1827, and the other on Salisbury Plain, in 1849. Upon these two lines depend all the results of the trigonometrical survey.

2944. Ramsden's Theodolite.

This instrument was made by the celebrated Ramsden, and first used in 1792. Since that time it has been in use at a vast number of stations, including the highest mountains in England and Scotland, the Hebrides, Orkney, and Shetland. It is now in as good condition as when it was first made, having never in all its travels met with any accident or ill-usage. Subsequent to the year 1843, the observations with it have been made by non-commissioned officers of the Royal Engineers. This instrument is a slight improvement on another made by Ramsden,—the 3-ft. theodolite of the Royal Society,—which was completed and first used in July 1787, but the two are almost identical. The divisions of the circle on the Ordnance Theodolite are rather closer than in the Royal Society's. The focal length of the telescope is 36 inches, and the aperture 2·5 inches, the magnifying power ordinarily used 54. The probable error of a single observation of a fine object under favourable circumstances is about 0·18″. The astronomical determination of the direction of the meridian has been effected at many stations with this instrument. In 1862 it was used at Fairlight, near Hastings, and St. Peter's Church, Isle of Thanet, in the extension of the English Triangulation into France and Belgium.

Many of the observations made with this theodolite have been to points upwards of 100 miles off (seen by means of a heliostat, a looking-glass reflecting the sun's light). The greatest distance ever observed was 120 miles, from Ben More in South Uist to a hill in Sutherlandshire.

The diameter of the circle of this instrument is 36 inches. The weight of the whole is 200 lbs.

2945. Ramsden's Small Theodolite.

This instrument is very similar in appearance and construction to the large instrument, but is only 18 inches in diameter. The focal length of the telescope is 19·5 inches, the aperture of the object glass 2 inches, and the ordinarily used magnifying power 30. The horizontal circle is read by three microscopes.

It has been used at a very large number of stations, many of them being church towers and spires. At Thaxted Church, of which the tower is 79 feet high, surmounted by a spire of 93 feet, the instrument was 178 feet above the ground. It was also used at St. Paul's Cathedral, over the cross. At one of the stations in the north of France, some 14 miles east of Boulogne, this theodolite was mounted on a scaffolding 75 feet high.

2946. Troughton and Simms' 24-Inch Theodolite.

This theodolite, of a totally different construction from Ramsden's, was made by Messrs. Troughton and Simms, at the commencement of the Irish Survey. In Ramsden's theodolites, the divided horizontal circle revolves with the telescope, while the microscopes which read it are fixtures. In Simms', the microscopes are connected with the telescope, and rotate with it, while the circle is fixed.

The focal length of the telescope is 27 inches, and the aperture 2·125 inches. The instrument has a repeating table, and is, strictly speaking, an altazimuth. The horizontal circle is read by five micrometer microscopes.

It has been in continual use at a very large number of stations, from 1829 until 1862, and, like Ramsden's theodolites, has been so fortunate as to escape accidents.

2947. Troughton and Simms' 14-inch Theodolite.

This instrument is one of excellent construction. The telescope has 2 inches aperture and 18 inches focal length, the ordinary magnifying power 40. The horizontal circle is read by three micrometer microscopes: the vertical circle by two micrometer microscopes. It is admirably suited for astronomical observations. It is, comparatively with the other theodolites exhibited, a new instrument.

2948. Airy's Zenith Sector.

This instrument was used between th[illegible]ars 1842 and 1850 in the determination of the latitudes of 27 statio[illegible]he principal triangulation of the kingdom On the destruction of R[illegible]'s Zenith Sector in the great fire at the Tower of London this instrum[illegible]as invented and constructed under the direction of the Astronomer Ro[illegible] George Airy. The first principle in the instrument is the arrangemen[illegible]aking successive observations in two positions of the instrument, face [illegible]nd face west, at the same transit of a star. The second principle was the [illegible]ubstitution of a level or system of levels for the previously used plumb-line. The third principle was the casting in one piece, as far as practicable, of each of the different parts of the instrument, in order to avoid the great number of screws and fastenings with which most instruments are hampe[illegible] and to secure if possible perfect rigidity

The focal length of the telescope is 46 inches, the aperture 3·75, and the magnifying power 70. The vertical arc is read by four micrometer microscopes.

The weight of the entire instrument is rather more than half a ton.

2949. Zenith Telescope.

This instrument has done much service in North America and in Scotland in the determination of latitudes. It is most simple in its construction, consisting of little more than a good telescope capable of being set to any zenith distance, and rotating round a long and very firm vertical axis. In the focus of the eyepiece, besides five ordinary transit wires, is a micrometer wire, adapted to measurement of zenith distance, to the extent of 45′. The mode of using the instrument is this: suppose two stars pass the meridian at nearly equal zenith distances, and within a few minutes of one another in point of time, the one star being to the north, the other to the south of the zenith; the observer sets the telescope for the first star (of course in the plane of the meridian), reads the micrometer wire, rotates the instrument 180° round the vertical axis, and looks for the second star. as it passes through the field he bisects it with the micrometer wire. The difference of the reading of the micrometer on the two stars leads to the immediate knowledge of the latitude, the indications of the level being of course taken into account. This instrument was made by Wurdemann of Washington, United States, America: it is a great favourite with observers, and certainly leads to the most excellent results.

2950. Portable Transit Instrument.

The small transit instrument exhibited as a telescope of 21 inches focal length and 1·7 inches aperture. The uprights are of mahogany. The telescope is provided with a reversing apparatus.

2951. Clinometer.

For determining the values of levels, such as are used in the zenith sector, zenith telescope, and other astronomical instruments. The two micrometer

screws at the right hand of the instrument are moved simultaneously. The value of one division of these screws corresponds to a change of inclination of the upper bar, of one second of angle.

2952. Standard Toise.

This bar of cast steel was formed to be a connecting link between the English yard and the "toise," which is the geodesic unit of length of so many countries of Europe. Its length in terms of the standard yard (about 76·74 in.) is known, from some 4,000 observations, with a probable error of one ten-millionth part of itself. It has been compared with the standard toise of Belgium, with that of Prussia, with the standard double toises of the Russian Geodetic Survey, with a standard toise of Vienna, and with the Spanish four-metre bar.

Connecting the survey of so many countries, this standard bar takes a place of the utmost importance in the determination of the figure of the earth.

The continental toises are generally measures "by contact;" that is, the measure is not indicated by lines on the bar, but by the entire length of the bar between its extremities.

2953. Thermometer Calibration Apparatus.

It is necessary in the comparisons of standards that the errors of the thermometers should be known to two or three hundredths of a degree Fahrenheit. The calibration errors of the best standard thermometers (such as those made by Casella for the Ordnance Survey) are extremely small, but it is necessary to determine what they actually are in order to correct the observations made with them. The apparatus consists of a cast-iron frame, having two parallel rods above, on which slides a microscope. The thermometer lying in a carriage below is read by the microscope, and by means of the micrometer screw on the right a small movement is communicated to the carriage and thermometer. Now, if we break off from the column of mercury a piece, say of 30° in length, and cause that piece to take different positions in the tube, it will be seen that we can by means of the micrometer and the microscope detect errors among the division lines; and finally determine as many errors as we choose.

2954. Isometric Drawing of Expansion Apparatus.

This drawing shows the interior of the room in which the comparisons of bars are made; it is a room 20 feet by 11, half sunken below the surface of the ground, and entirely surrounded and covered over by an outer building. In the drawing are shown the three stone piers for carrying microscopes. In the experiments depicted, two microscopes are used and stand upon the outer piers. The long boxes contain bars, one hot, the other cold; they are alternately brought under the microscopes. In this manner the absolute expansions of two Indian standards, two English standards, and two American standards have been determined. The drawing shows the flexible tubes which form supply and waste pipes for the currents of water, hot and cold, which maintain the bars at steady fixed temperatures.

SURVEYING INSTRUMENTS EXHIBITED BY THE ORDNANCE SURVEY DEPARTMENT OF THE ROYAL PRUSSIAN GENERAL STAFF, BERLIN.

2955. Distance Measuring Plumb-line (ancient construction by Breithaupt, No. 71).

2956. Distance Measuring Plumb-line (construction of 1874, by Breithaupt, No. 97).

2957. Distance Measuring Plumb-line (construction of 1875, by Sprenger, No. 106), with magnifying glass, screw-driver, screw-pin, and dust brush.

2958. Surveyor's Table Stand (ancient construction, by Baumann, No. 53), and three screws in the transport case.

2959. Surveyor's Table Stand (improved construction, by Baumann, No. 82).

2960. Surveyor's Table ad (construction of 1874, by Breithaupt, No. 91), with case fo staff-head, and three screws in the transport case.

2961. Surveyor's Table ad (construction of 1875, by Sprenger, No. 113).

2962. Surveyor's Two Table Boards, with oilcloth cover, in a leather bag.

2963. Surveyor's Two Tabl Boards, without oilcloth, in a leather bag.

2264. Distance Staff.

2965. Universal Instrument, latest construction.

With such instruments as these the topographical survey of Prussia is carried on The Trigonometrical Department of the Royal Survey lays down the network of triangles, and gives to each individual trigonometric point its geographical longitude and latitude, and its elevation according to the Trigonometrical Department, in a similar form to that shown in No. 2962. This sheet (section Kalisch) contains the trigonometrical points which are marked thus "⊕," the station being at the point of intersection of the two lines. The minute net drawn upon the sheet is on the scale of 1·25,000, to which the topographical surveys are executed.

The surface covered by each section between 54° and 55° N. lat. amounts to about 2 2 square (German) miles.

The position of the square in the sections in relation to the degree net is shown by the two general tables appended to No. 2962. Here the section Kalisch is coloured red.

The *Universal Instrument* (2965) is one of the instruments used for measuring the angles of the triangles of the *first* order by the Trigonometrical Department of the Royal Land Survey. The one here exhibited was taken out to Kerguelen's Land by the expedition for observing the transit of Venus.

SECRETARY OF STATE FOR INDIA.

Photographs of Instruments used for the Great Trigonometrical Survey of India.

2966. Photographs of the Great Theodolite for the great trigonometrical survey of India. Designed by Lieut.-Colonel A. Strange, F.R.S.

Constructed by Messrs. Troughton and Simms. Telescope, aperture $3\frac{1}{4}$ inches, focus $36\frac{1}{2}$ inches. Horizontal circle, diameter 3 feet. Vertical circle, 2 feet. (Photograph about $\frac{1}{8}$ real size.) No. 1. General perspective view. No. 2. Elevation in plane of pillars. No. 3. Side elevation, showing vertical circle and microscopes. No. 4. Side elevation, showing counterpoises of vertical circle and microscopes. No. 5. Horizontal circle (plan of upper surface). Vertical axis socket. Horizontal microscope arms, &c. (plan of under surface). No. 6. Horizontal circle (plan of under surface). Table, pillars, horizontal microscope arms, &c. (plan of upper surface).

2967. Photographs of the Zenith Sector for the great trigonometrical survey of India. Designed by Lieut.-Colonel A. Strange, F.R.S.

Constructed by Messrs. Troughton and Simms. (Telescope, aperture 4 inches, focus 4 feet. Sector, diameter 3 feet.) (Photograph about $\frac{1}{8}$ real size.) No. 1. Front elevation, complete. No. 2. Front elevation, telescope and sector removed. No. 3. Back elevation, complete. No. 4. Side elevation, complete. No. 5. Telescope and sector (side elevation). Plinth (plan of inner surface). Vertical axis. Cradle, with microscopes and levels (plan).

2968. Photographs of the Electro-Chronograph for the great trigonometrical survey of India.

Constructed by M. Eichens and M. Hardy, of Paris, under the superintendence of Lieut.-Colonel A. Strange, F.R.S., assisted by M. Leon Foucault, member of the Institute. (Photograph about $\frac{1}{8}$ real size.) No. 1. Front elevation. No. 2. Back elevation. No. 3. End elevation, showing clockwork. No. 4. End elevation, showing connexion of pointer slide with barrel. No. 5. Plan of upper surface-barrel removed.

2969. Photographs of the Transit Instrument for the great trigonometrical survey of India. Designed by Lieut.-Colonel A. Strange, F.R.S.

Constructed by Messrs. T. Cooke and Sons. Telescope, aperture 5 inches, focus 5 feet. (Photograph about $\frac{1}{12}$ real size.) No. 1. General perspective view. No. 2. Elevation in plane of telescope. No. 3. End view of transit axis and levels. No. 4. Front view of transit axis and levels. Bearings and their foundation plates (plan of upper surfaces). No. 5. Bearings and their foundation plates (side and inner elevations).

2970. Photographs of the Diagonal Transit Instrument for the great trigonometrical survey of India.

Constructed by Messrs. T. Cooke and Sons, under the superintendence of Lieut.-Colonel A. Strange, F.R.S. Telescope, aperture 2·64 inches, focus 34·6 inches. (Photograph about $\frac{1}{6}$ real size.) No. 1. Elevation in plane of telescope. No. 2. Telescope raised for reversal.

2971. Photographs of the Vertical Circle for the great trigonometrical survey of India.

Constructed by M. M. Repsold, of Hamburg, under the superintendence of Lieut.-Colonel A. Strange, F.R.S. Telescope, aperture 1·9 inch, focus 18·8 inches. Vertical circle, diameter 12 inches. (Photograph about $\frac{1}{8}$ real size.) Front and side elevations.

II.—HYDROGRAPHY.

ADMIRALTY—HYDROGRAPHIC DEPARTMENT.

Instruments comprised in the ordinary Outfit of one of H.M. Ships employed on Surveying Service.

2972. Azimuth and Altitude Instrument.

2973. Theodolite, 5-inch.

2974. Sextant, observing, and stand.

2975. Sextant, used for measuring angles between terrestrial objects, to fix the position of a ship or boat when engaged in sounding.

2976. Sextant, pocket or box.

2977. Artificial Horizon, roof.

2978. Artificial Horizon, black glass, portable. Used in travelling.

2979. Micrometer Telescope. Rochon. Invented by the Abbé Rochon. Date 1812. Used (in surveying) for the measurement of distances by means of a base a few feet in length.

It is formed of two prisms of rock crystal, the one cut parallel to the axis of the crystal, and the other parallel to one of the faces of the pyramid; these are placed one on the other in contrary directions, and cemented together in a cell which slides in the body of the telescope, and by means of a slit in the direction of its length, so that the prism may be moved along the tube by means of the index and a milled head screw, which is connected with the prism-box inside.

The scale on the telescope tube is divided into minutes of arc, and by means of a vernier, reading to seconds.

A table accompanies the instrument, giving the distances for the angular measurement of each foot of base.

2980. Heliostat. A mirror for reflecting the sun's rays, used in trigonometrical surveys to indicate, from great distances, the position of a station.

2981. Station Pointer, 6-inch. For placing the observer's position on the chart from angles taken between three objects, the relative positions of which are known.

2982. Protractor, circular, with arms. For projecting the angles of a survey.

2983. Protractor, circular. Bullock.

2984. Protractor, semi-circular.

2985. Protractor, rectangular.

2986. Protractor, horn.

2987. Parallel Rulers.

2988. Scale, brass, graduated.

2989. Scales, ivory ; set of 6.

2990. Beam Compass, wood. For the accurate measurement of long sides in projecting triangulation.

2991. Drawing Instruments; magazine set.

2992. Drawing Instruments, for service in boats.

INSTRUMENTS OCCASIONALLY FURNISHED TO OFFICERS ENGAGED IN NAVAL SURVEYING EXPEDITIONS.

2993. Reflecting Circle. Troughton.

2993a. Allen's Reflecting Circle, for repeating the observations and reading the angle on any portions of the circle, so as to eliminate errors of graduation or workmanship.

W. Watson and Son, London.

2994. Sextant, Travelling, small.

2995. Sextant, Observing, with micrometer and indicators. Davis.

2996. Sextant, Sounding, Double. Beechey.

2996a. Rowland's Patent Sextant. Consists of two sextants on the pillar frame principle, mounted parallel, with their faces towards each other, in such a way that one telescope answers for both. One sextant measures angles in a forward direction, the other in a backward, so that if an angle between two points be measured on the larger sextant, and a third point taken between the other two, the angle between this third point and the other two can be measured at one observation, and the sum of these two angles should equal the first. *W. Watson and Son, London.*

2997. Sextant, Pocket, Double. George.

2998. Dip Sector. By Troughton. For measuring the angle between the apparent and true horizons, from an elevation above the surface of the earth.

2999. Artificial Horizon, portable. George.

3000. Stadiometer. Blakey. An ordinary telescope fitted with a sliding measure and linear arrangement on object-glass ; designed for the purpose of determining the distance apart of two ships, the height of the masthead of the second ship being known.

3[illegible] Optical Opposite. Raper. An instrument for determining and preserving a position in a direct line between two objects.

3002. Beam Compasses, tubular.

3003. Beam Compasses, bar, metal.

SOUNDING MACHINES AND AP[illegible]ATUS USED BY H.M. SHIPS IN DEEP SEA [illegible]LORATION.

3004. Clam, for bringing sp[illegible]imens of the sea bottom. Sir John Ross; date 1818. Desig[illegible]nd used by Sir John Ross in H.M.S. "Isabella" in Baffin B[illegible]

The claw is kept open by hinged arm[illegible]vithin; whilst thus open the outer case is kept up, and a spike connect[illegible] with the arms projects below the claw. On striking bottom the spike [illegible]ses the arms up; this releases the outer case; as the claw closes t[illegible]des down, and the contents in claw are secured.

3005. Brooke's Rod, for bringing up specimens of the sea bottom, and weight detaching apparatus (about 1856). By Mr. Brooke, Midshipman, United States Navy. Used, with various modifications, to 1868.

In the first instrument employed in the United States Navy the valve securing the specimen of the sea bottom was not applied, quills being inserted in the tube for that purpose. The hook, with the wire and ring, supports the sinker weight as long as there is strain on the sounding line; the moment that strain ceases by the rod touching sea bottom, the sinker weights turn the suspending hook, and the wire being released the sinkers slide off as the rod is drawn upwards.

3006. Brooke's Rod, another mode of detaching sinker weights; date 1857. Used in sounding North Atlantic.

3007. Skead's Weight Detaching Apparatus; date 1857. By Mr. F. Skead, Master R.N., H.M.S. "Tartarus." Used in Mediterranean Sea survey.

A 68 lb. shot (represented by the wooden ball, exact size) is slung with wire, and the detaching apparatus attached. On reaching sea bottom, the small weight on the apparatus, which had till this time been kept above the hook by the weight of the shot, is freed, and, falling, reverses the hook; the shot is thus left behind. The small weight is roughed to secure a small portion of the sea bottom.

3008. Bonnici's Weight Detaching Clam; date 1857. By Mr. C. Bonnici. Used in Mediterranean Sea survey.

A 68 lb. shot (represented by the wooden ball) is slung with wire, and the claw attached, the weight of the shot preventing the claw opening. On reaching sea bottom and the line slackened, the arms of the claw fall by their own weight, and the sinker is released.

3009. Bulldog Clam, for bringing up specimens of the sea bottom; date 1860. Used in H.M. ships "Bulldog" and "Porcupine," North Atlantic Ocean.

The claw is kept open by a tubular sinker weight, resting on the four horns. When the weight is detached on reaching sea bottom, the india-rubber bands contract, closing the claw, and thus securing the sea bottom contained within it.

3010. Fitzgerald Sounding Machine, combining apparatus for detaching the weight and procuring specimens of the sea bottom; date 1867. By Lieutenant Fitzgerald, R.N., employed in H.M.S. "Cordelia," in deep sea sounding between Jamaica and Cuba.

An iron sinker weight (represented by wood model) is hooked to the side of the sounding bar, and the hook or lever, to which the sounding line is attached, is inserted in the hole at the upper end of the bar. When suspended, the weight of the sinker keeps the lever in the hole and the bar nearly vertical. On reaching sea bottom, the scoop is driven into the ground, and the hook being freed by the slackening of the sounding line the weight falls over; the action of hauling in the sounding line reverses the bar, unhooks the weight, and the scoop closes with its contents.

3011. Hydra Weight Detaching Apparatus; date 1868. By — Gibbs, artificer, H.M.S. "Hydra." Used in sounding Atlantic and Indian Oceans.

The wooden models represent (exact size) iron sinkers, each of one hundredweight; they are suspended on the sounding tube by the iron ring and wire, to a button which protrudes through a steel spring on the sliding rod above, the spring being kept back by the weight of the sinkers. On reaching sea bottom and the sounding line slackening, the rod slides down, the sinker weights then resting, the steel spring throws the suspending wire off, and the weights are left behind as the tube is drawn through them. A butterfly valve within the tube at the bottom secures a portion of the sea bottom.

3012. Baillie Weight Detaching Apparatus; date 1872. By Navigating Lieut. C. W. Baillie, R.N. In general use in H.M.S. "Challenger."

Iron sinkers of half a hundredweight each (exhibited in wood models) in numbers sufficient for varying ocean depths, are placed on the sounding tube and suspended by the ring and wire to two shoulders that project from the sides of a sliding rod working in the upper part of the sounding tube. On touching sea bottom and the sounding line slackening, the sinker weights draw the sliding rod downwards, and the shoulders passing within the sounding tube, the wire is thrown off, and the weights released. The lower portion of the tube, to which a valve is attached, receives the specimen of the sea bottom.

3013. Burt's Bag and Nipper, for sounding in moderate depths without stopping the ship's way. Invented by Mr. Gould, an American (about 1812).

The bag is first soaked in water to render it air-tight, and when used is inflated; a wooden tube and peg is affixed for the purpose. The sounding line is placed in the nipper or snatch attached to the bag, and on the sounding lead

being cast from the ship, the whole is thrown overboard, the inflated bag floating as the line runs through the attached nipper, the bag keeping immediately over the descending lead.

On the lead reaching the bottom, indicated by the spring of the bag, no more sounding line will pass through the nipper, and the place where it is thus nipped is the vertical depth of water as marked on the line.

3014. Massey's self-registering **Sounding Machine;** date 1800. Adapted for moderate depths. In use in H.M. Navy.

3015. Ericsson's self-registering **Sounding Machine;** date 1836. For sounding in moderate depths.

This instrument records the vertical depth irrespective of the amount of sounding line thrown out from the ship.

The depth is ascertained by the compression of air within a glass tube, the value of the compression, in accordance with depth, being recorded by the quantity of water passing into the tube as the air is compressed, and a scale adapted to it.

3016. Cup Lead. For sounding in depths not exceeding 1,000 fathoms, and to procure specimens of the sea bottom (about 1858); model. Originally used in sounding North Atlantic.

3017. Tube Lead. For sounding in depths not exceeding 1,000 fathoms, and procuring specimens of the sea bottom; date 1872; model. In use in H.M.S. "Challenger."

3018. Specimens of Sounding Line. Used in H.M. ships. No. 1. used in "Challenger"; No. 2. medium.

These lines are constructed of the best Italian hemp.

No. 1 line is one inch in circumference; 100 fathoms (or 600 feet) weighs 18 lbs. 9 oz. When wet this line breaks at a minimum strain of about 14 hundredweight.

No. 2 line is 0·8 inches in circumference; 100 fathoms weighs 12 lbs. 8 oz., and it bears a strain of about 10 hundredweight when wet.

THERMOMETERS AND APPARATUS FOR PROCURING SEA WATER, USED IN DEEP SEA EXPLORATION.

3019. Six's Thermometer, with protected bulb. Negretti. Designed by Fitz Roy and Glaisher (about 1860); used in H.M. ships "Bulldog" and "Porcupine" in North Atlantic.

3020. Six's Thermometer. Hydrographic Office pattern, bulb not protected. Casella; date 1867. Used in H.M. ships "Lightning" and "Porcupine" in North Atlantic.

This instrument (the full bulb of which was unprotected by an outer glass casing) was found to be affected by pressure, and gave erroneous results at great ocean depths, and this led to the construction of the protected bulb thermometer (3021).

3021. Six's Thermometer. Miller pattern; bulb protected as proposed by Dr. Miller. Casella; date 1869. In use in H.M.S. "Challenger:" generally adopted, after being tested to three tons on the square inch.

The full bulb is protected by an outer glass casing. The errors of these thermometers are determined under pressure, and are found to be reduced to the limits of about 1·2 for depths of 2,500 or 3,000 fathoms.

Two protected bulb thermometers which were broken by pressure at a depth of 3,875 fathoms in the Atlantic Ocean.

3022. Johnson's Metallic Self-registering Thermometer. Invented by Mr. Henry Johnson (about 1858). Not in general use.

3023. Saxton's Metallic Self-registering Thermometer (about 1855). Used on the United States Coast Survey. Not in general use.

3024. Water Bottle. In ordinary use for bringing up water from ocean depths. [Superseded in H.M.S. "Challenger" by Buchanan's design.]

3025. Water Bottle. Buchanan's; date 1872. A drawing. Invented by Mr. Buchanan, one of the scientific civilian staff attached to "Challenger."

3026. Barometer, Diagonal (about 1750). Watkins and Smith, London.

3026a. Barometer with Thermometer.

Paul Greiner, Hamburg.

The baro-thermometer, an instrument for measuring the depth of the sea, is also intended for recording the temperatures and the salinity of the sea water.

III.—MISCELLANEOUS.

ROYAL GEOGRAPHICAL SOCIETY OF LONDON.

3027. Instruments used by the late **Dr. Livingstone** in his *last* journey. *The Royal Geographical Society of London.*

A pocket chronometer, by Jas. McCabe, 194, Royal Exchange, London.
A sextant, by John Dalton, of Hartlepool.
Hypsometrical boiling apparatus, by Casella.
2 boiling point thermometers, by Casella.
1 ordinary thermometer, by Casella.

3028. Instruments invented by Staff-Commander C. George, R.N., Curator of maps and instruments to Royal Geographical Society. Made by Mr. H. Porter (late Cary), optician, London.

[illegible] **Mercurial Barometer, an Instrument for** [illegible]

peculiarity is, that the tube and cistern are carried empty.
[illegible]e mercury is secured separately in an iron bottle.
The cistern is used as a funnel.
It is filled, when required, by the traveller, using the spiral cord, which is kept in the tube while being filled.
Circular motion is given to the spiral cord, which, acting on the dense body of the mercury, forces the cord upwards, and out of the mercury, and with it the air bubbles, leaving a s[illegible] as shown by the mercury always having a convex surface w[illegible] [illegible]alling.
A spare tube is in same b[illegible]
The instrument has been te[illegible] H. Scott, Esq., Director of the Meteorological Office, London, a[illegible] the Kew Observatory, Richmond, with good results. It is now being [illegible] travellers on the African lakes, and various parts of the world.

3030. Portable Artificial Ho[illegible]zon.

Its improvement consists, not i[illegible] reduced size and weight, but in its mechanical arrangements, form, [illegible]te price.
Secures altitudes near the hor[illegible] [illegible] as 3°; saves time, and no waste of mercury.

	lbs.	oz.		in.		in.
Large size, weighs in the case -	4	10	measures	9	by	5
Small ,, ,, ,, -	1	11	measures	6	by	3

3030a. Artificial Horizon, constructed by W. Herbst.
M. W. Herbst, Pulkowa.

M. Herbst's artificial horizon differs from that commonly used in the following points :— It is a box of rectangular shape, the mercury is enclosed in the lower part of the box, and brought up on the silvered copper-plate by means of a screw; it admits of easy cleansing of the reflecting surface without any loss of mercury; its folding rectangular roof is covered with mica.

3030b. Plumb Level, or Artificial Horizon.
Louis Brocher, Geneva.

The instrument consists of a vertical rod, a horizontal disc, and a small suspension chain. In operating, the instrument should be held suspended by the chain, like a plumb-line, the eye being on a level with the disc; the projection of the plane of its upper and lower surface determines the horizon. As the rod is graduated, and as the distance from the eye to the rod can be ascertained by means of a line, the observer can determine approximately the *size* of the object—building, tree, or mountain—and ascertain its height, if not absolutely, at all events relatively. This instrument, which was originally invented with a view of supplying a means (in sketching from nature) of ascertaining in any place the level of the horizon (a matter indispensable for correct perspective), may be, and has already been, useful to architects, engineers, geographers, tourists, and also to agriculturists, for drainage purposes. Its small size renders it easy to carry, and the rapidity with which observations can be taken enables them to be repeated almost without intermission.

3031. The Double Pocket Sextant, an instrument for travellers.

It can be used on shore with artificial horizon, in obtaining altitudes near the zenith; also as two single sextants, one of which can be used in case of the other being damaged; or one can be used by an assistant, and the other retained by the observer.

It can measure angles of nearly double the arc which can be measured by the ordinary sextant.

It can be used for the simultaneous measurement of two homogeneous angles.

For laying out curves for railways and harbours, it is invaluable to the civil engineer and marine surveyor.

3032. Universal Tripod Stand, an instrument for travellers.

May be used for five instruments, viz.:—

Sextant (for Lunars).
Telescope.
Barometer.
Prismatic compass.
Artificial horizon.

3033. Large Double Sextant (6 in. radius) for taking two lunars simultaneously; an instrument for travellers.

3033a. Capt. George's Improved Double box Sextant.
Henry Porter.

This instrument enables the observer to take right and left angles simultaneously, thus combining rapidity of use with great portability.

3033b. Box Sextant with improvement of wheel head to telescope, and case. *Henry Porter.*

3034. Pocket Compass, for bearing of objects, &c., an instrument for travellers. *O. S. Bishop.*

A combination of the ordinary compass and the dipping needle. The advantage aimed at is, that it will act at or near the magnetic pole when the ordinary compass ceases to be of any use.

3035. The Inclined Reflecting Horizon, an instrument for travellers. *H. Porter.*

This instrument is used with the usual artificial horizon, to which it may be said to form an appendage or adjunct. By its aid such increased power is given to the sextant and artificial horizon that altitudes of the heavenly bodies can be measured from the zenith to 30° below it, and also altitudes from the horizon to 30° *above* it and 30° below it; this the sextant and artificial horizon have hitherto failed to do. It consists of a glass reflector, supported by a framework, which has its underside ground mathematically level, and this side floats on the surface of the mercury, carrying the reflector at an angle of about 30° with the natural horizon, and when properly made will always float on the mercury at the same angle; it has been tested by numerous observations, with satisfactory results. *See* observations and drawings.

3035a. Capt. George's Improved Portable Artificial Horizon. *Henry Porter.*

This combines the reservoir for holding the mercury with the trough for observation, the two being cast in one piece of iron, with a stopcock to let the mercury run from the reservoir into the trough and back again when not in use. This instrument has a perfectly worked parallel glass floating upon the surface of the mercury, thus giving a perfectly brilliant surface and protected from the action of the wind ruffling the surface of the mercury during an observation. This instrument combines the most perfect horizontal surface, with exceeding portability (being less than one sixth the size of the ordinary mercurial artificial horizon) and the greatest facility in use.

3036. Ramsden's Great Theodolite, with other instruments and apparatus, employed by Major-General Roy in the trigonometrical survey. *Royal Society.*

3037. Large Levelling Instrument by Cary. *Royal Society.*

3038. Large Levelling Instrument by Troughton and Simms.

3039. Five-Inch Theodolite by Adams. *Royal Society.*

SURVEYING AND OTHER INSTRUMENTS LENT BY VARIOUS CONTRIBUTORS.

3040. Theodolite of Early Form.
School of Military Engineering, Chatham.

3041. Complete Set of Instruments for Surveying in mountainous tracts :—

a. Square box, containing parallel rule, with diopters and telescope, compass and level.
b. Surveyor's table.
c. Three-legged stand with bronze head ; each leg in two parts, to be screwed together.

The whole set to be carried on a knapsack.
Survey Office, Christiania, Norway.

3041a. Compass Binocular.
Robert E. Barker, Clifton, Bristol.

This combination will be of service to officers of the army or navy, also to exploring parties, travellers, or tourists. With it the compass bearings of any object in the field of the glass can be seen directly in the mirror attached. It adds very little to the weight of the glass, can be fitted to any binocular, and will readily go into the original sling case with it. Rough surveys may be made with it in positions where larger and more costly instruments would not be available.

3042. Clinometer, by General Naser.
Survey Office, Christiania, Norway.

This apparatus consists of a thin circular brass box, vertically fixed on three screws, by means of which the exact position can be maintained. Through the centre of the box moves an axis, supporting on one side a small telescope, and on the other a needle, following the movements of the telescope, and giving the readings of the tangential scale engraved on the box. By a small exchange-wheel, the angle between the optical axis of the telescope and the horizon is multiplied 10 times, thus enabling the operator to read off the tangent with sufficient accuracy. The horizontal distance between two objects being known, the difference in height can easily be found. The instrument can be used with advantage for distances up to 15 miles, and generally for all levelling purposes.

3043. Clinometer, by G. Oisen.
Survey Office, Christiania, Norway.

This apparatus consists of a square box, in which a pendulum moves on a horizontal axis. At the lower end of the pendulum a tangential scale is fixed, which doubly reflects in two small mirrors placed over the top of the pendulum. On the outer side of the box a small telescope is fixed, movable in the vertical plan. Pointing through this glass to an object whose horizontal distance is known, you can, by reading off the division on the scale that coincides with the object, easily find the difference in height by referring to a table. The instrument needs no corrections, is very handy, and easily transported, but can not be used at such long distances as the clinometer constructed by General Naser.

3043a. Ship's Clinometer. *L. Casella.*

3044. Pocket "Mensor." An improved arrangement or combination of various mathematical or philosophical instruments for measuring and other purposes. *Ridley Henderson.*

This instrument, when folded up, measures 3 inches square by 2¼ inches deep, and weighs 2 lbs. 2 ounces.

It contains within a box, hinged together in three parts, twenty instruments, as follows :—Anemometer, aneroid barometer, clinometer, goniometer, thermometer, circumferentor, protractor dial, prismatic compass, hypo-thonite, quadrant, spirit level, limb and sights for taking altitudes, sun-dial, callipers, plummet, magnifying lens, Nicol prism, scale of inches, scale of chains; added to which are arranged two tables of constants and useful formulæ, and an easy method of ascertaining the variation of the magnetic needle.

It is a measurer of time, heat, velocity, and pressure, also of height, depth, length, and breadth; and of horizontal, vertical, acute, and oblique angles.

It is made so portable in form and weight as to enable it to be carried in the pocket, and yet it possesses sufficient size and strength to render it a reliable and useful companion to military, civil, and mining engineers, geologists, mineralogists, railway and land surveyors, and travellers.

3045. Theodolite-Level. A combination of the two instruments. *Patrick Adie.*

3046. Patent Level. A combination of the Y and Dumpy patterns. *Patrick Adie.*

3046a. **mpy Level,** of improved construction.
Joseph Casartelli.

With graduated circle, for taking horizontal angles, and ball-and socket otion greatly facilitating its adjustment, especially on hilly or uneven ground, d saving the wear of the adjusting screws. The instrument being made of rd gun-metal, and the centre being long and accurately ground, renders it ttle liable to derangement.

3047. Theodolite with 3 inch circle.
Messrs. Troughton & Simms.

The telescope is of the bent [illegible] small rectangular prism in the axis. The light received by [illegible] urned through the axis of the instrument, and an image of [illegible] med outside the pivot. By this construction the instrument may [illegible], and possess at the same time considerable optical power.

3047a. Five Inch Theodolite. *Joseph Casartelli.*

In making this theodolite the object has been to reduce the number of parts and simplify the construction. [illegible] double conical bearings to the axes, with a ball-and-socket adjustm[illegible] spring verniers to the altitude circle, producing an easy and smooth [illegible]. The whole is made of gun-metal.

3047b. Travellers' Theodolite and Stand. *L. Casella.*

3047c. Travellers' Theodolite and Stand, with telescope in centre. *L. Casella.*

3047d. Cary's Improved 5-in. Theodolite, with improved rack adjustment to cross webs of eye-piece, and improved form of tripod foot. *Henry Porter.*

3048. Theodolite (10·5 in.), in which the vertical arc is jointed on an ordinary sector, and covered with a variety of scales. Made by Sissons, London. *Major M. L. Taylor, R.A.*

3049. Repeating Theodolite, horizontal circle 14 cm. in diameter, vernier $\frac{1}{3}°$, sliding rule 30″ specified, glass covered telescope, 12 lines free aperture, magnifying 25 times, vertical circle in $\frac{1}{2}°$, sliding rule 1′ specified. Level to arrange the telescope in two positions, telescope for penetration, and to lie down.
A. and R. Hahn, Cassel.

Besides the addition of the movable level to the telescope, this instrument possesses a new arrangement for its vertical movement. A small female screw with right and left threads on opposite sides is inserted near the base of the bearer. Corresponding to these threads are male screws tightly fastened to the bearer, and, by turning the female screw to the inner or outer side, the height of the telescope is increased or diminished.

3050. Universal Theodolite (Bende's construction), horizontal circle 12 cm. diameter, vernier $\frac{1}{3}°$, sliding rule 30″ specified, repetition and glass covered telescope, 15 lines free aperture, mag-

nifying 35 times, adapted for revolving and lying down, level for setting; tangent screw exactly 1 mm. range.

A. and R. Hahn, Cassel.

By means of this instrument elevations can be measured directly with the tangent instead of by the arc or its chord as hitherto. Its advantage over other screw instruments consists in its peculiar construction, which admits of using the micrometer screw in the measurement of angles up to 45°, whilst till now angles to about 10° only have been so measured. The relation between the reading on the screw and the height or distance to be measured is a simple geometrical one.

3051. Repetition Theodolite (No. 148), with stand and leather case. *Otto Fennel, Cassel.*

Horizontal circle with covered silver border 14 cm. in diameter, graduated into one-third degrees, vernier to 20 seconds. Achromatic double lenses, orthoscopic telescope. Vertical circle with vernier graduated to minutes.

3052. Metford's Improved Theodolite, made by F. Pastorelli, under the direction of the inventor. *Francis Pastorelli.*

Description of the Instrument.

Levelling Gear.—It consists of three left-handed screws with the balls fitting closely to their beds on the under surface of the traversing box; they are secured by an elastic three-cornered plate, having boxes at their ends to protect them from dust and grit. The lower ends of the three screws pass through a triangular plate with broad ends, with sufficient spring to permit the female screws to be slightly twisted.

Traversing Stage.—The main hollow centre of the instrument carries a circular disc $3\frac{1}{2}$ inches in diameter and $\frac{3}{16}$ of an inch thick; the traversing stage is a flat plate $5\frac{1}{2}$ inches in diameter; in its bottom the levelling screws are seated as previously explained. The upper surface has a ring round its edge the depth of the circular disc. There is a $\frac{1}{16}$ of an inch hole in the stage to let the plumb cord traverse with the instrument; the disc will traverse 1 inch in any direction from the centre. To secure the instrument there is an upper plate screwed to the ring, so that the stage becomes a very shallow box; there is also a washer that keeps out dust and grit. A three-arm pinching screw running on the hollow centre secures the disc.

Horizontal Limb and Vernier Plate.—The horizontal limb and vernier plate are solid; the latter has mounted upon it a compass, circular bubble, and a memorandum plate; also attached to it is the tangent motion. The limb is divided to read 20 minutes, the vernier to 30 seconds.

Bracket Support of Vertical Limb and Telescope.—On the side of the main pivot is attached a strong curved bracket with two arms at the top. This bracket has a T section throughout; to it is fixed the vertical circle and female centre. The telescope and vernier circle, with its tangent motions, are fixed on the male centre. The main spirit bubble is fixed at the back of the vertical circle; there is a screw in the bracket for perfecting its adjustment. The axis of the telescope is suspended over the axis of the instrument, and admits of a transit motion; this is an important improvement.

Tripod Staff Head.—This is an adoption of W. Froude, Esq., C.E., by which steadiness is obtained, which is of great importance in taking angular measurements. The checks are set wider apart, the leg joints being similar

to an inverted mortar with strong trunnions, which can be tightened in their bisected cylindrical bearings by means of capstan-headed screws. As wear goes on they can always be kept perfect; this cannot be done with the ordinary staff head.

3052a. Metford's 7-inch Theodolite, with curved arm instead of the usual structure for carrying the vertical circle, and telescope, mounted on his traversing stage, with legs, invented by Mr. Froude. *H. Husbands, Bristol.*

3052b. Metford's 4-inch Theodolite. Instead of being mounted on the traverser is placed on the ball movement, and is more especially recommended for very steep and hilly ground, and for preliminary surveys. *H. Husbands, Bristol.*

3052c. Theodolite. An extremely old, if not unique, instrument, purchased by the late Sir James South as a rarity. In the original oak box. *G. J. Symons.*

3053. Small Theodolite, for rapid operations.
Geneva Association for Constructing Scientific Instruments.

This instrument presents the following advantages:—
The telescope is reversible to give the correction of the zero of the vertical circle.
The position of the level is symmetrical
The divisions are strongly marked for rapid observations.
The vertical circle has two divisions; the one to show degrees and minutes, the other tangents. This latter division shows the fractional figure of inclination at once without computation.

3054. Gambey's Theodolite.

3055. "Bussolen-Theodolite," a representation of an instrument invented by the exhibitor, for observing, with a microscope, the exact position of the magnetic needle.
Professor Joseph Schlesinger, Vienna.

3056. Theodolite, horizontal circle, graduated scale of 13 cm. diameter, divided on silver to $\frac{1}{3}°$; two verniers, reading 30 seconds, two turning and regulating double magnifiers, with diaphragms, On the alhidada a spirit level. Telescope of 28 mm. aperture, 32 cm. focal distance. Ramsden eye-lens with movement. The tripod can be shifted on the wooden stand.
Frerk and Son, Hanover.

The construction of the instrument is as low and simple as possible. The rotating axis is directed from below upwards, and is situated between the telescope supporters. It is made of steel, and the socket of the upper part rests, by means of a regulating screw, on the hard glass point of the axis. The low supports are fitted with easily opening cap-pieces, which act with constantly uniform elastic pressure on the pivot of the telescope. By these means the telescope can be easily adjusted, the pivots of the axis reversed,

and, in every position, the micrometer work can be placed and reversed without difficulty. The screens serve at the same time as bearers of the magnifying glasses, so that every shadow on the nonii has been avoided.

The circular divisions are executed on the exhibitor's own machines, which have also the requisite exactness for large instruments with microscopical division.

The tripod stands of the three theodolites (Nos. 3056, 3057, and 3058) have all purposely been chosen of different arrangements.

3057. Small Repeating Theodolite, horizontal circle graduated scales of 10 cm. diameter, divided on silver in $\frac{1}{3}°$, with two verniers, reading minutes, with glass cover, movable magnifier, with diaphragms. Vertical circle 10 cm. diameter, in silver in $\frac{1}{3}°$, with double verniers reading minutes, with telescope of 23 mm. aperture, 16 cm. focal distance, three micrometers with spiral springs. On the alhidada a spirit level; a second for placement on the telescopic axis; a third for levelling on the telescope, to be placed upright or turned over in both positions.

Frerk and Son, Hanover.

The repetition theodolite is a very complete instrument, which occupies little space. The water-level on the telescope axis serves essentially for the examination of the normal position of both axes. But as it forms a cross with the alhidada-level, it is very easy, by means of both, to adjust the instrument horizontally, without necessitating any turning of the axis. The correction of the telescope socket has been arranged according to a new and simple manner.

3058. Small Theodolite, horizontal circle graduated scale 10 cm. diameter, on silver in $\frac{1}{3}°$, two verniers, indicating minutes, two movable magnifiers, with diaphragms, altitude circle 8·5 cm. diameter, with a double vernier indicating minutes. Telescope 23 mm. aperture, 24·5 cm. focal distance, two micrometers with springs. In the centre of the alhidada, box level.

Frerk and Son, Hanover.

This small theodolite is also very compendious, but more simple, and of quite a different form and construction. It is frequently constructed for polygon measurements, and for use in forests. The holders of the magnifying glasses throw no shadow on the nonii. The encased water-level can be easily taken out. The axis rotates with a hard glass point on a regulating hard screw. The adjustment on the stand is as far as possible without tension, but so that the plumb line is always hanging exactly in the line of extension of the rotatory axis. All plumb lines can be suspended at pleasure, either long or short.

3059. Large repeating Theodolite, with arc and altitude circle, divided into $\frac{1}{6}°$; with verniers 10 sec. for direct reading to 10″.

Dennert and Pape, Altona.

3060. Theodolite with circles of six and four inches.

Julius Wanschaff, Berlin.

This theodolite has been constructed (of greater durability than usual) for making very accurate measurements. The division is not the exhibitor's;

only those on the reflecting circle, and on the universal instrument, were made with the exhibitor's new machinery.

The circles on both these instruments have no errors which could be detrimental, or which can be ascertained by the instruments themselves, since the exhibitor's dividing machine (of 90 cm. diameter) is only arranged for copying, and the normal-division itself being correct as far as 1·2 seconds.

The horizontal circle on the theodolite can be turned, and is provided with a contrivance for centering; the nonii indicate at a division of—10 to 10 minutes—10 seconds. Those on the altitude circle indicate at a division of —20 to 20 minutes—30 seconds.

3061. Ten-inch reflecting **rismatic Circle,** similar to that of Pistor-Martin. *Julius Wanschaff, Berlin.*

3062. Universal Instrun **with eight-inch Circles,** and microscopical reading; fold echanism.

Julius Wanschaff, Berlin.

The drums on the universal instrun t indicate direct four seconds, but they have only figures of half the valu n order to have at once the mean in measurements by the addition of the readings of the oppositely situated microscopes.

By using the reversing mechanism, the handle of the same must be held very firmly, especially by the replacement in the sockets.

3063. Levelling Instrument with telescope of 15″ focal distance, 1·6″ aperture; a so-called compensation plane with rotating level. *A. Ott and G. Coradi, Kempten.*

This "compensation level" is a levelling instrument with telescope, which can be turned round its optical axis and reversed in its sockets. The water level is firmly fixed to the telescope, and can be turned in plumber blocks round its own axis in such a manner that at a revolution of the telescope of 180° the scale of the water-level can, in the two reversed positions of the same, be always turned upwards.

The object of this arrangement is to render one's self independent of the errors occurring by damage of the telescope rings, and to give to the engineer at all times the possibility of correcting the instrument as easily from any position as in a levelling instrument with reversible telescope, with exactly equal ring diameters and fixable water-level. By this arrangement the tedious reversing of the telescope and the adjusting of the water-level, which easily give rise to injury, will be rendered superfluous. Other constructors have endeavoured to obtain this result by the employment of double-cut water levels; a correct construction, however, of such instruments is very difficult, and any errors occurring cannot be corrected.

3064. Iron Levelling Staff, Reflector, and box level, angle mirror, and hydrostatic balance in case.

Zimmer Brothers, Stuttgart.

This instrument, cross-disc, with iron bar, angular mirror, and water level in a box, serves for marking right angles and drawing perpendiculars. The same is so far new that it is made entirely of metal; on stony ground or in frosty weather it is preferable to the cross-disc with wooden pole.

3065. Reflecting Hypsometer.

Zimmer Brothers, Stuttgart.

The cross staff and mirror hypsometer.

The cross staff serves likewise for marking right angles and drawing perpendiculars.

The mirror-hypsometer is used for measuring the height of trees, &c.

These instruments are particularly useful for foresters and agriculturists, on account of their being easily carried about.

(See "Holzmessekunst," by Prof. Dr. Baur, Hohenheim).

3066. Small Universal Instrument for measuring heights, &c., with stand. *Zimmer Brothers, Stuttgart.*

Small levelling instrument and theodolite in one, for measuring heights, horizontal angles, &c., and for levelling and marking right angles. Useful to foresters and agriculturists, on account of its cheapness, and capability of being easily handled.

3067. Sextant of Aluminium, constructed by A. Petri, Rostock. *Prof. H. Karsten, Rostock.*

3068. Hypsometer (thermo-barometer), graduated in $\frac{1}{200}$ths of a degree centigrade, and in millimetres representing the corresponding tensions of aqueous vapour.
Will. Haak, Neuhaus am Rennweg, Thüringen.

3068a. Hypsometer, large, with thermometer. *L. Casella.*

3068b. Hypsometer, small, with thermometer. *L. Casella.*

3069. Hypsometer for levelling. To ascertain elevations up to 500 metres by observing the ebullition point of water.
Prof. Helmert, Aix-la-Chapelle.

3070. Hypsometer for levelling. To ascertain elevations up to 4,550 metres by observing the ebullition point of water.
Prof. Helmert, Aix-la-Chapelle.

3071. Apparatus constructed for observing the ebullition point of water, in the use of hypsometers.
Prof. Helmert, Aix-la-Chapelle.

3072. Distance and Altitude Measuring Theodolite, by Dennert and Pape, in Altona, with stand.
Prof. Helmert, Aix-la-Chapelle.

The theodolite is intended for topographical surveys. The division of the circle is so fine that frequently the reading of one index will suffice, its position being appreciable to 1 minute with the lens. As the stand can be set up very firmly, the vernier arm is not movable together with a spirit level, but fixed.

3073. Theodolite with two Vertical Circles.
Geodetic Institute of the Royal Polytechnic School at Munich, Prof. Dr. von Bauernfeind.

The Theodolite with two Vertical Circles was made by Ertel & Son, of Munich, from the exhibitor's design. It seems in the first place suited for

investigations as to the relative value of the vernier and microscope readings of five divisions, and, secondly, for observations upon the magnitude of terrestrial refractions and their variation with temperature and the pressure of the air. The exhibitor has not yet described his instrument, because the number of observations made with it is still too small to allow certain results to be deduced from them. The instrument, however, perfectly fulfils its purpose.

3074. Repeating Theodolite, horizontal circle, 15 cm., with covered division circle of altitude 12 cm. *A. Bonsack, Berlin.*

Repeating Theodolite.—Both circles are divided on silver; the first into $\frac{1}{3}°$ with two verniers to half minutes, the second into $\frac{1}{3}°$ readable to one minute by one vernier. The telescope is adapted for distance measurements by a method invented by me, and which has been strongly recommended by Herr S. Woyike, who used it in operations on the Ostbahn. With the stand.

3075. Theodolite with Microscopes on the horizontal circle. *J. W. Breithaupt and Son, Cassel.*

Theodolite for Geodetic purposes.—Horizontal circle 20 centimètres in diameter, with microscopes showing [illegible] seconds directly; the fine division is protected by a cover; the verniers on the vertical circle show 10 seconds; orthoscopic telescope for *Durchschlagen* and *reversal*, with arrangement for distance-measuring and with reversion spirit-level and level on the axis of the telescope. The circles may be shifted for *Satz* observations. The microscopes have parallels and reversion scales on glass. This theodolite belongs to the Royal Forest Academy at Münden.

3076. Pocket Theodolite.

J. W. Breithaupt and Son, Cassel.

Capable of employment, on account of its small dimensions, in very confined spaces, in mines, &c.

3077. Francis' Patent Pocket Theodolite, made by Negretti and Zambra. *George Francis, C.E.*

The improvements claimed for this invention are, 1st, its portability and cheapness; 2nd, its simpleness and easy application; 3rd, the proportionate increase of length between the sights for dialling; 4th, it is less liable to error in taking horizontal angles; 5th, its adaptability for taking the angle of an undulation or gradient; 6th, it requires little or no adjusting; it combines with the theodolite a clinometer, protractor, and plotting scales for reference from 1 to 60 feet to the inch.

At *each* setting of the instrument, the following observations can be taken: 1st, the horizontal angle of the back and forward drafts to $\frac{1}{60}$th part of a degree; 2nd, the magnetic bearing to $\frac{1}{4}°$; and 3rdly, the rise or fall in the draft to $\frac{1}{10}°$ [illegible] also in inches to the fathom for perpendicular and base.

3079. Tachymeter (theodolite), with stands.

Bau Deputation, Hamburg.

3079a. Theodolite (Tachymeter), from the mechanical workshops of Dennert and Pape in Altona.

This was specially constructed by these mechanical engineers according to the directions of the Survey Department for the measurement of distances and heights, as well as for geodetical purposes. The arrangement has been

such, that besides lightness, sufficient stability is afforded for work of such a nature. The circles are divided to 10′, so that they can be read without the aid of the vernier to 5′, and that the operator is not obliged to leave his place during the work for the purpose of reading at the circles.

For distance and height measurement, after the centre horizontal thread has been adjusted to any point of the levelling staff, and the readings taken, and the difference of the readings for the two threads, as well as the reading of the centre thread, is noted in the field book.

For the observation of the line of direction of other stations, the circles are fixed by the clamping screws, and the exact adjustment obtained by means of the micrometer screws.

3080. Repeating Theodolite, with microscopes.
S. C. Dennert and C. W. Pape, Altona.

Repeating Theodolite with Reading Microscopes.—The tripod stands on screws which turn upon separate supports. The instrument is fixed to the stand by a brass plate pressed up against the lower surface of the head by a screw and spiral spring. The box rests upon an annular horizontal surface and can be turned accurately round its axis, an arrangment which enables the repetition movement to be quite accurately made. The vertical axis of hardened steel and the horizontal circle are firmly united with the box, and round the vertical axis turns a second box, having two double arms and serving as a support for the bearers of the axis of rotation of the telescope, which is arranged for reversal and carries the vertical circle, with an arrangement for vertical repetition movement. On the other end of the axis is the counterpoise with a graduated circle. The telescope has an achromatic object glass and orthoscopic eye-piece upon which a prism and sun glass can be placed. The cross wires consist of spiders' threads and are held by adjusting screws. Provision is made for illuminating the cross threads for observations at night. The two levels are divided into sixths of degrees, and by means of two screw microscopes accurate readings to 10 seconds may be obtained.

3081. Theodolite for Horizontal Angles with microscopical reading. *Imperial German Navy (August Lingke and Co.).*

3082. Theodolite, with microscopical reading.
Ed. Sprenger, Berlin.

Theodolite, with horizontal and vertical circles 0·17 meter in diameter.—Both circles with microscopic reading to 2 seconds. Focal distances of telescope, 0·32; magnifying power, 36 times. The tripod has a complete circle, and a third microscope to screw for the exact and easy examination and determination of the errors of division. The substructure and axis bearer are of a single piece of cast steel, coated with chloride of platinum for protection from rust. The circles are solid and funnel-shaped, by which means unequal expansion is avoided; this is not the case with spoked circles. The object-glasses are by Fraunhofer's successors in Munich.

The Topographical Department of the Royal Land Survey has exhibited a telescope ruler, which is now introduced by the Department. It has double verniers and a folding telescope, and is also furnished with a double bubble-tube, rendering the instrument very useful for levelling. The distance-measure is removable, but so contrived that no screw is visible outside, so that nothing can act upon it.

3082a. 3-inch Theodolite. Three sheets of drawings. "Dividing Machine." *Troughton and Simms.*

... **drant,** of boxwood. One side engraved as usual, ... are numerous figures and a movable index.
William Sykes Ward.

...84. **Gunter's Quadrant,** of boxwood.
William Sykes Ward.

3085. **Quadrant,** of brass; one side divided as a geometrical square, the other with movable circle and index, signs of the zodiac, and various figures. *William Sykes Ward.*

3086. **Levelling Instru...** ...th telescope to lie down.
Meissner, Be... .... Müller and F. Reinecke).

This levelling instrument is disti... ...d by its simple and especially ...hangeable arrangements for corre...

3087. **Reflecting Prism Circle,** 10 in. diameter.
Meissner, Berlin ... Müller and F. Reinecke).

3088. **Reflecting Prism Circle,** 6 in. diameter.
Meissner, Berlin (H. Müller and F. Reinecke).

The reflecting prism-circles can be recommended on account of their excellent execution, in optical as well as in mechanical respects, and also on account of their cheapness.

3089. **New Levelling Instrument,** constructed by A. Geppert, completed by F. Miller. *F. Miller, Innsbruck.*

This instrument is adapted especially for geometricians and engineers at work in mountainous countries. The arrangement is as follows:—The vertical revolving axis is placed perpendicularly by means of 4 screws. The horizontal circle is removable by means of a vernier giving two minutes, and by adding a sail may be changed into a sailing carriage. The astronomical telescope will magnify 15 times with 14 degrees of depression or elevation. The inclination of the telescope is measured by a micrometer screw. When placed in proper contact the instrument is very suitable for tracing. Its uses are: Direct and indirect levelling, measuring height and distance, horizontal angles, &c., marking down the above on paper.

3090. **Land Surveying Apparatus,** of simple construction, by A. Geppert, completed by F. Miller. *F. Miller, Innsbruck.*

This apparatus, chiefly designed for work requiring no particular exactitude, and which a beginner with little experience in surveying may be trusted to execute, consists of a "Nativ," in which a round plank is screwed, and serves as a leaf. On the edge of this leaf are put 4 brass plates, with a deviation scale at distances of 90°, for forming right angles. The distance of the two dioptra is 30 cm.; one bears two horizontal cords, in the other a little sledge with movable sight, which can be moved in a vertical direction. If the index of this slide stands at zero on the division fastened to the dioptra, the line of sight is horizontal when the tablet of the instrument is put in action. By moving the slide, and measuring the way which has been passed, the instrument can be used for indirect levelling distance and mensuration of heights and tracing. A chord drawn over both dioptra allows the formation of perpendicular lines.

3090a. Surveying Table, with **Plummet Rule,** as used by the topographical surveys in Russia.

The Topographical Department of the Imperial Russian General Staff at St. Petersburg.

The plummet rule is provided with an altitude circle, and, besides, arranged as an instrument for measuring distances by adjusting the horizontal strings of the two water-levels which are attached to the plummet rule; the lower one is for regulating the horizontal position of the surveying table, the upper one for regulating the horizontal position of the altitude alhidada, by means of a micrometer screw acting against the beam of the alhidada.

3091. Jaehn's Polymeter, with plane-table.

Schmidt and Haensch, Berlin.

Jaehn's "polymeter" enables the measurement of the distance of two points, or their relative position in the horizontal direction, and their differences of altitude to be obtained in a mode quite different from previous methods of operation. Both may be effected—1, simultaneously; 2, by one observation; 3, from a single point; 4, without any calculation; 5, by a mechanical setting out of the measured distances and heights in proportion upon the plane of the measuring table; 6, in any scale.

3092. Double Prism, on **Jesse's System.**

Schmidt and Haensch, Berlin.

3093. Experimenting Model (quarter of the natural size) for the preparation of measuring bars to a new *base apparatus.*

Carl Bamberg, Berlin.

Experimental Model.—The steel tube is bored through cylindrically in an axial direction, closed at the ends and filled with mercury, which also passes into a glass tube, closed above, and communicating with the boring. The height of the column of mercury in the glass tube will be a measure of the alteration of the length of the scale by change of temperature. The proportions of the cavity of the passage in the steel and glass tubes are so arranged that every change of length in the scale is increased 100 times in the glass tube.

This instrument has been made as an experiment by order of the Royal Prussian Land Survey.

3093a. Drawing of a Base Measuring Apparatus, with employment of the measuring bars mentioned with the above apparatus.

Carl Bamberg, Berlin.

3094. Distance and Altitude Measuring Plumb-line (telescope ruler), executed, according to the directions of Prof. Helmert, by J. W. Breithaupt and Son, Cassel.

Prof. Helmert, Aix-la-Chapelle.

The telescope ruler is also for topographical surveys. It has a distance-measure on glass; the altitude-circle is furnished with two verniers, although, as a rule, only one of them need be read off; moreover, the position of its index may be ascertained with the lens. A spirit level is combined with the vernier arm; a mirror enables it to be seen from the eye-piece. The instrument also has levels and adjusting screws for the horizontal axis of rotation of the telescope, and also parallel ruler.

...angular Prism.

...eodetic Institute of the Royal Polytechnic School at Munich, Prof. Dr. von Bauernfeind.

The Three-sided Angle Prism, invented by the exhibitor in 1851, serves for the measurement and marking out of right angles, and depends upon the deviation of light by refraction and total reflection. *See* Bauernfeind's "Elemente der Vermessungskunde," 5th edition, 1876, Stuttgart, F. G. Cotta, Vol. I., pp. 37–39 and 164, 165.

3096. Distance Measuring ...sm.

Geodetic Institute of ...yal Polytechnic School at Munich, Prof. Dr. ...ernfeind.

The Distance-measuring Prism, also ...vented by the exhibitor in 1851, but not applied to measuring distances ...til afterwards, serves for marking off isosceles triangles in which the equa... sizes are definite multiples of the base. It is used in the same way as the three-sided angle prism *See* Bauernfeind's "Elemente der Vermessu...ngskunde," 5th edition, Vol. I., pp. 39–40 and 167 (No. 4), and Vol. II., ... 90, 91.

3097. Pentagonal Prism.

Geodetic Institute of the Royal Polytechnic School at Munich, Prof. Dr. von Bauernfeind.

The Five-sided Angle Prism, invented by the exhibitor in 1869, serves not only for the measurement and marking off of right angles and half right angles, but especially for the laying down in position of two inaccessible points, or points which cannot be directly observed. It may replace the prismatic cross No 4 *See* Bauernfeind's "Elemente der Vermessungskunde," 5th edition, Vol I, pp. 44–46 and 166–168

3098. Prism Cross.

Geodetic Institute of the Royal Polytechnic School at Munich, Prof. Dr. von Bauernfeind.

The Prism Cross was invented by the exhibitor in the year 1851, and was then described in a separate memoir ("Das Prismenkreuz," published by F. Palm). It is described with later improvements in Bauernfeind's "Elemente der Vermessungskunde," 5th edition, Vol. I., pp 168–175, especially 173–175. Its object is identical with that of the subsequently invented five-sided angle prism (No. 3), which, as already stated, may be used instead of it

3099. Intersecting Compasses (Arcograph).

Geodetic Institute of the Royal Polytechnic School at Munich, Prof. Dr. von Bauernfeind.

The Arcograph serves to describe upon a given chord a circle which embraces a given peripheral angle. The exhibitor, by this invention, has supplied the wants of the practical geometrician in solving, graphically, and without construction Pothenot's problem and all the problems which are described in geodesy as "Ruckwartseinschneiden". *See* Bauernfeind's "Elemente der Vermessungskunde," 5th edition, Vol. II., pp. 167–173.

3099a. Portable Compass. *Colonel Degen, Bobruisk.*

3099b. Normal Compass of the Imperial German Navy, with stand, diopter apparatus, two compass-cards, &c.

Carl Bamberg, Berlin.

The normal *rose A.* of the normal compass is arranged for reversal so that at any time a determination of the error of collimation of the zero-line to the axis of the needle may be effected, and we are enabled to make a determination of the collimation of other roses of ordinary construction, but of the same diameter, by comparison. For measurements on land the gimbals may be fixed and the compass itself be brought to a horizontal position by means of screws.

3099c. Boat's Compass, with equipments in order to be employed as a small azimuth compass. *Carl Bamberg, Berlin.*

The case of the boat compass serves for its transport, and also (by the removal of two pieces) as a binnacle. In combination with the dioptric apparatus and the stand, the boat compass is a small, handy, and accurate azimuth compass.

3099d. Boat's Fluid Compass. *Carl Bamberg, Berlin.*

The rose of the fluid compass is furnished with a float, so that pressure, and therefore also the friction on the pivot, are reduced to a *minimum*. The cap and pivot are made of ruby, so that they do not easily wear, and a stop becomes unnecessary.

3099e. Albini's Registering Steering Compass.

Elliott Brothers.

The instrument consists of a steering compass, with clock and apparatus attached, for printing on a slip of paper the direction of the ship's course every five minutes, the clock giving the exact time for eight days without winding. An instrument of this description placed in the captain's cabin would thus enable him to have a record of a whole voyage.

3099f. Prismatic Compass, with improvement of ring to hold more safely in the hand. *Henry Porter.*

3100. Photograph of a Base Measuring Apparatus, in course of construction for the United States Lake Survey, Detroit. *A. Repsold and Sons, Hamburg.*

Base-measuring Apparatus.—A measuring rod 4 mètres in length is used, consisting of a steel and a zinc rod, enclosed together in a wide iron tube, and with divisions upon platinum at the ends. The measuring rod rests on its extremities (below the divisions) upon its supports, by which the advantage is attained that the support remains the same for two positions, and, therefore, only one has to be arranged for each new position. Before making a measurement microscopes are placed, at a suitable level, upon separate supports above the rod-supports, and beneath these the rod is carried forward. To set off the daily termination a cylinder is arranged, by level, perpendicularly under the last microscope on the small hemisphere of one terminal plate, by the microscope a division on the upper terminal surface of the cylinder is read off in the two positions differing by 180°. The apparatus is accompanied by a comparator for the comparison—(1) of the measuring rod with a standard mètre; (2) of the measuring rod with a spare measuring rod. In the first case the standard mètre is laid, together with the measuring rods, upon a

c... res in length, and compared in order with the intervals of t... rod divided into mètres. For this purpose the carriage is moved to and fro upon the base piece under two microscopes placed upon a common bearer. This bearer may be pushed along the whole length upon the base piece (like the standard mètre upon the carriage). In the second case the two measuring rods are laid side by side upon the carriage, and compared under the microscopes, one of which is attached to the common bearer, and the other to a special arm of the base piece at a distance of 4 mètres from the former. The comparator is also arranged, if the purchaser wishes it, for the comparison of the standard mètre (*à traits*) with a yard end measure (*à bout*). For this pur... ...ll cylinders with scales are applied to the standard yard in order to comp... ...itable portions of these scales with the mètre; then the sum of the length... the cylinders up to the portions of the scale employed is found by putti... two together directly. The whole comparator is to be enclosed in a w... ...ase, in order to keep the measures at an equable temperature.

3101. Geodetical Tachy..., a representation of an instrument invented and construc... the exhibitor, for conducting measuring operations in their minutest details.

Professor Joseph Schlesinger, Vienna.

This instrument consists of a circl... divisions, mounted in a movable frame, that can be adjusted so as to ...he circle in any given direction. It is also provided with a rule to draw angles.

3102. Eckhold's Omnimeter, for measuring linear distances by one and the same operation. *Elliott Brothers.*

This instrument is a transit theodolite, with an apparatus for measuring by one operation the distance of an object or staff of a determined length, and its height over or under the level line of the instrument, the former with the accuracy of a good chaining, the latter with the precision of a perfect levelling, and accomplishes the work of theodolite, level, and chain with a great economy of time.

3103. Apparatus for Determining the Exact Time of an Earthquake. (Seismochronograph.)

Royal University at Breslau, Prof. Dr. Lasaulx.

3104. Abney's Level. The instrument was designed by Capt. Abney, R.E., for military reconnaissances. It measures vertical angles by means of a spirit level attached to a graduated arc, which is capable of moving round an axis. The object whose angle of depression or elevation is to be ascertained, is brought into the field of view, and the spirit level is then moved till the bubble is in the centre. When in this position the bubble is seen in a reflector placed in the body of the tube; an opening being left for the purpose. *Elliott Brothers.*

3105. Elliott's 14-inch improved **Dumpy Level,** with compass for taking levels and bearings. *Elliott Brothers.*

This instrument, being provided with an object glass of large aperture and short focal length, and sufficient light being thus obtained to admit of a

higher magnifying power in the eye-piece, the advantages of a much larger instrument are obtained. A mirror is placed in the bubble, so that the operator can see, while reading the levelling staff, if the instrument keeps its proper position; this being necessary on soft and spongy ground.

3105a. 14-in. Dumpy Level, with improved rack adjustment to cross webs. *Henry Porter.*

3106. Repeating Theodolite.
Meissner, Berlin (H. Müller and F. Reinecke).

The repeating theodolite has the advantage of the particular firmness of the telescope supporter.

3106a. Quadrant used by Captain Cook during his several voyages. *Richard Caulfield, LL.D., F.S.A., Cork.*

3107. Sextant, by Ramsden. *Prof. Winnecke, Strassburg.*

3107a. Improved Box or Pocket Sextant. To enable the observer, when sounding from a moving boat or vessel, to take both angles in fixing a position without delaying to read off one angle before taking the other.
Captain J. E. Davis, R.N., F.R.G.S.

This is effected by means of a supplementary arm and vernier, not affected by moving the proper arm unless connected by means of the hook and pin. When connected the vernier of the supplemental arm corresponds with that of the other vernier *minus* 20 degrees.

When used the arms are connected, and the larger angle is taken first, the hook is then pushed back, and the supplemental arm remains to record that angle, which is read off after the small angle is taken.

Particularly useful when fixing positions in sounding and the boat or vessel is moving quickly.

3107b. Improved Sounding Sextant. To enable the observer, when sounding from a moving boat or vessel, to take both angles in fixing a position without delaying to read off one angle before taking the other. *Captain J. E. Davis, R.N., F.R.G.S.*

When used the pawl of the indicator is attached to the movable arm and moves with it. When the larger angle has been taken the finger is applied to the capstan-headed screw, which at once clamps the indicator and frees the pawl from the arm, the smaller angle is then taken and read off; the arm is then moved up to the indicator, and the larger angle read off; the capstan-headed screw is loosened and the pawl drops, connecting the indicator again with the arm.

3107c. Improved Sextant. For observing and recording a number of observations without the necessity of reading off at the time of observation, or removing the eye from the telescope, effected by means of a micrometer movement affixed to the tangent screw, and indicators applied to the arc.
Captain J. E. Davis, R.N., F.R.G.S.

This is effected by means of a micrometer movement affixed to the tangent screw, and indicators applied to the arc.

It larly adapted for observing lunar distances, circum-meridian altitudes, equal altitudes for time. For position in bad weather, &c.

Its advantages are. —

1. It enables the inexperienced observer to take observations with as much facility as the more practised.
2. By greatly multiplying the number of observations, the instrumental and personal errors are reduced to a minimum.
3. At sea, it enables a number of observations to be made in a short time without being dependent (as is often the case) on one.
4. The differences of the altitudes being all equal, the check on the time-taker is apparent.
5. For night observations it i larly adapted.
6. The micrometer movement thrown out of gear at pleasure.

The sextant has been submitted to stronomer Royal, who states that "*the arrangement is simple, very littl e to get out of order, and I should* "*think very effective.*"

The many sources of error to which the astronomical sextant is liable, either from the different expansive qualities of the materials of which it is composed or the mechanical difficulties attending its construction, render it a less perfect instrument than it is gener upposed to be.

There is also a personal error, incid to every observer with the sextant or any other instrument, and this is frequently augmented in night observations by the necessity of dilating the pupil to the utmost when observing, and suddenly contracting it in reading off by the aid of the strong rays of a bull's-eye lantern.

With these sources of error, any improvement that can be devised to bring either the instrument to a greater state of perfection, or to deduce a greater degree of accuracy from the observations taken with it, is a step in the right direction, and it is anticipated that by the use of the micrometer movement combined with the indicator, the number of observations can be so multiplied as to reduce the error to a minimum.

3107d. Double Telescope Sextant, with reduced arc and natural angles. *Patrick Adie.*

This instrument was invented and patented by Mr. Adie some years ago, but owing to difficulties in simplifying the adjustments, not yet surmounted for lack of time, has not been publicly introduced. It is an arrangement of the object ends of two telescopes, united by a common hollow axis; the rays from each are received on total or other reflecting surfaces placed at an angle of 45° at the centre of either end of this axis, along which each of the reflectors sends the rays at right angles; these rays are received by two other reflecting surfaces, each occupying half the field of the eye-piece. Thus both objects are seen at the same time. A motion—half that of the movable telescope is given to the eye-piece, to correct the parallax of reflection from prisms placed at an angle of 45°.

3107e. Cary's Improved Edge Bar Sextant. Special construction to prevent expansion or contraction in different temperatures. *Henry Porter.*

3107f. Portable Sextant. *John Browning.*

3107g. Six-inch Sextant. *John Browning.*

3107h. Sextant by Syeds, to be used in a fog. *Capt. C. George.*

3107i. Davis's Quadrant. *H. Porter.*

3107j. Pocket Sextant, by Cary, used by Captain Henry Bristow, of the Quartermaster-General's Department, in making the military maps of the north of Spain, for the use of the British army, under the Duke of Wellington, during the Peninsular war.
H. W. Bristow, F.R.S.

The sextant is a convenient instrument used for measuring the actual angle between any two well-defined objects, in whatever direction they may be placed, so that the angle does not exceed 140°; and without requiring more steadiness than is necessary for seeing the objects distinctly.

The pocket sextant was formerly used in military and maritime surveying, for fixing points and for filling in the details of maps. It has been superseded by the form known as the *bore-sextant* (the principle of which is the same as in the larger sextant), which will measure the angle between any two objects to a single minute.

3108. Drawing of a Horizontal Goniometer for determining geographical longitude without a chronometer.
H. Haedicke, Demmin, Pomerania.

The instrument of which this is a drawing serves, in the first place, to determine by direct reading the angle formed by the line joining two stars (*a*—*b*) with the horizon. The handling of the instrument is for this purpose similar to that of the sextant; that is to say, the moment must be noted when the star line is covered by the hair line of the instrument. That an observation may be carried out on board ship, the instrument is provided with an arrangement which enables the position of the scale with respect to the artificial horizon to be fixed at the moment of the observation, so that the angle can afterwards be quietly read by means of a vernier.

When in this manner the angle of a second star line (*c*—*d*) to the horizon has been determined, a simple subtraction sum will give the angle between the star lines *a*—*b* and *c*—*d*. Should there be a planet among the stars *a, b, c, d,* it becomes possible, by means of a proper astronomical table, to calculate the astronomical time as well as (if the local time be known) the geographical longitude of the place of observation.

3109. Tacheometer of Gentilli, a telescopic instrument for measuring heights and distances in surveying difficult country. Without calculations it measures accurately distances up to 400 meters, or over 1,300 feet, with an error of less than $\frac{1}{2000}$. *Dr. Karl von Scherzer.*

This instrument was invented by M. Amadeo Gentilli, an eminent Austrian engineer at Vienna. Its use is for the measurement of heights and distances in the survey of difficult ground, and it has proved especially useful in surveying the contour-lines of mountainous districts. The means by which it measures the distance is an apparatus which obliges the lunette to traverse a precise and unvarying angle. The test of value of this instrument is the fact that, with a magnifying power of 40, it measures distances up to 400 meters with such exactness that the maximum error is less than $\frac{1}{2000}$ of the distance.

3109a. Laslett's Metroscope. For measuring inaccessible heights and distances, and for levelling; also used as an optical square. *Thomas N. Laslett.*

3109b. Metroscope. For the determination of dimensions of distant objects (a drawing).

Dr. Snellen, Physiological Laboratory and Ophthalmological School, Utrecht.

Before the objective of a telescope are placed two mirrors, one above the other, each occupying one half of the field of view, and inclined to the plane of the objective at an angle of $\frac{1}{8}$°, the angle between them being 90°. On a cross bar, at each side, a mirror parallel to the first is moveable. Looking through the telescope, by means of these two sets of mirrors, two objects are seen straight above each other, and [illegible]e mutual distance of these objects must be, at whatever distance they [illegible]m the observer, equal to the distance of the two outer mirrors. (H[illegible]ch der Ophthalmologie, von Graefe und Saemisch, III p. 203.)

3110. Level, with independent bubble, Gravet's system, with stand. *M. Tavernier Gravet, Paris.*

3111. Portable Repeating Circle (14 centimetres). *T. & A. Molteni, Paris.*

3112. Patent Surveying Level. *Francis Pastorelli.*

This instrument combines several important improvements, including increased facility in use, greater steadiness and freedom from vibration and possibility of derangement, accurate adjustments, and great durability.

Tripod and Staff Head.—Stability is of the utmost importance. This is secured in the staff head (which is the adoption of a plan by Wm. Froude, Esq., C.E.), which has the checks set wider apart, the leg joints being similar to an inverted mortar with strong trunnions, which can be tightened in their bisected cylindrical bearings by means of capstan headed screws. As wear goes on they can always be kept perfect; this cannot be done with the ordinary staff head.

Ball Joint and Clamp.—The instrument is free to move with 20° of inclination. This is most important, as much valuable time is saved, more especially upon hilly ground, as it can be almost set instantaneously.

Adjustments.—The parallel screws work in movable hemispherical nuts, which are held in seats in the parallel plates, those in the lower being held in brackets. Their action permits the upper plate to be worked at an inclination of about 15° without their being strained or twisted. By their means the upper parallel plate is made to clamp or set free the inverted cup on the vertical axis of the instrument; in addition, they cause it to heel over to perfect the adjustment, so as to bring the main bubble in the centre of its run whenever a force is applied to them greater than is necessary to clamp the inverted cup.

Suspension of Telescope.—The telescope is solidly fixed to its base, which is parallel to the axis of it; it has a female screw with a true surface which fits on to the gun metal centre, so that when the instrument is reversed in any direction the main and circular bubble is retained in the centre of their run. Around the telescope are two gun-metal collars, accurately turned and ground to a perfect circumference; by their means are adjusted the mechanical and optical axis of the telescope and the line of collimation; the main bubble is dead fitted; it neither admits nor requires adjustment, as it is done in construction.

Diaphragm.—The diaphragm with its collimating screws cannot be disturbed. A grooved channel is formed in the eye end of the telescope, into which they are sunk, and a cylindrical ring conceals them from sight, thus keeping them intact. This is one of the important adjustments of the instrument.

3112a. A 12-inch Level mounted on the Ball movement. *H. Husbands, Bristol.*

The 12-inch level is mounted on the ball arrangement, the combined invention of Mr. Metford and Mr. Froude.

3113. Levelling Instrument with Telescope 40 cm. long, arranged for folding down and turning in its sockets, with stand. *A. Bonsack, Berlin.*

The bearers are closed by springs. The horizontal circle is divided on silver to $\frac{1}{3}$°, and adapted for reading to one minute.

3114. Compensation Level. *J. W. Breithaupt and Son, Cassel.*

A portable instrument. It possesses the important advantage, that, with it, without previous correction, we may level correctly, even if the telescope-cylinders are unequal, provided that the spirit-level is correctly adjusted, which may be easily ascertained by turning it round in its points of suspension. By means of the tangential screw the spirit-level is brought to equilibrium in both positions of the telescope, and the mean of the two readings is taken. By this operation all errors are compensated. The divided head of the tangential screw serves at the same time for distance-measuring; and, besides, a distance measure on glass is inserted in the eye-piece of the telescope for direct measurement.

3115. Reflecting Circle, according to Pistor and Martins. *J. W. Breithaupt and Son, Cassel.*

3115a. Improved Reflecting Circle of Pister and Martins. *The Pulkowa Observatory.*

A full description of the patent reflecting circle of Pister and Martins in its original construction is given by the inventors in the Astronomische Nachrichter, vol. xxiii. In the exhibited form general improvements are introduced by the inventors on Professor Dallen's suggestion; for instance, all correction screws of the prisma are removed, the stiffness of the main body is considerably increased, the different parts of the instrument are more symmetrically disposed, the telescope and the dark glasses are separated from the radius, on which mirror and prism are fixed, means are given for cross observation to the extent of 288°, &c. Also, the stand for observations on shore is in parts changed and rendered more practical.

3116. Precision Levelling Instrument, with telescope of 15″ focal distance, 16″ aperture, a so-called **Compensation Level** with turnable water-level, according to new patent construction. *A. Ott and G. Coradi, Kempten.*

3117. Levelling Instrument with horizontal circle. *Imperial German Navy (August Lingke and Co.).*

3118. Large Levelling Instrument, with folding down telescope and fixed ether-level; above it a reflector, the objective 35 mm. aperture, and 45 cm. focal distance. *A. Frerk and Son, Hanover.*

advantage that any wearing that may be produced by the screws may be at once corrected without the aid of the mechanician. The instrument is particularly adapted for levellings of precision; that now exhibited was employed in this way in the European measurement of a degree by Prof. Spangenberg.

3127. Instrument for the Construction of Altitude Curves. *Bau Deputation, Hamburg.*

3127. Variable Scale.

This instrument, which was invented by F. H. Reitz, facilitates plotting a point on a contour line from the two nearest points, the altitudes of which are determined. *See* **3217a.**

3128. Plan 1 : 20,000 in frame under glass.

3128a. Hamburg and its Environs, scale 1 : 20,000, engraved by H. Petters. *Bau Deputation, Hamburg.*

3129. Plan 1 : 4,000 in frame under glass.
Bau Deputation, Hamburg.

3129a. Plan of Hamburg and its Environs. Official edition. According to the land survey, &c., engraved by S. Siebert; scale 1 : 4,000. *Bau Deputation, Hamburg.*

3130. Photograph of a Circle of Altitude, objective of 21''' aperture, diameter of circle 10½''. Latest construction of the instruments of a similar kind extensively in use in Russia for determining geographical localities.
A. Repsold and Sons, Hamburg.

3131. Paugger's Patent Dromoscope.

This dromoscope is circular, and has almost the shape of the ordinary chronometer.

Its diameter is about 22 centimeters, and its height (thickness) 7 centimeters. On the upper part there is a fixed compass card, with two hands, besides a graduation running to 45 degrees to the right and left, which lies below these hands (scale of deviation and variation). The inner mechanism of the instrument is a perfect calculating machine; it exhibits for any desired course the exact tangent formula of the deviation of the compass when the contrivance for turning it has been put in motion. On the lower or back part of the instrument there are five scales or graduations marked A, B, C, D, and E; and corresponding with these graduations are five set screws (not visible in the photograph). With these adjusting screws, and the scales belonging to them, the five co-efficients of deviation for any ship can be indicated.

By means of this instrument the deviation of the compass, either of the course or azimuth, is indicated merely by stopping the hand.

A printed description accompanies the instrument.

3132. Pendulum Apparatus. Great Trigonometrical Survey of India.
Kew Committee of the Royal Society, Kew Observatory.

3134b. Folding Alhidada or Sight-Vane, large size, for topographical surveys. *M. Georges Sarasin, Geneva.*

With the plane table to scales of from $\frac{1}{200}$ to $\frac{1}{20000}$, so constructed as to give relatively with considerable accuracy, notwithstanding its small volume for the sake of portability, measures of distances by the aid of a sight *stadia*, the measure of inclinations by means of a clinometer furnished with a verneir which gives a reading to three minutes, and consequently the measure of the differences of level, as well as a sketch of the horizontal lines on the ground. It is possible to *check* any inaccuracies of centering by verniers diametrically opposite to one another, and by turning the telescope end for end. There are also means of regulation and correction.

3135. Signalling Apparatus (Aëroclinoscope), by Major Kromhaut. *Prof. Buys-Ballot, Utrecht.*

This apparatus consists of four movable discs and two fixed hollow cylinders. Two of the four movable discs *never* enter the space between the cylinders; the other pair remain *constantly* between the fixed cylinders, but may very easily be placed in six different positions clearly to be distinguished from afar.

The two discs *f i* may be brought very easily close to one another and to the first cylinder or the second cylinder; or they may be more or less separated, one close to one of the cylinders, or both or neither of them. We have then six combinations. Each of the two other movable discs may be hidden, also by another chord, by the cylinder next to it, or be placed close to it or at a double distance. Three positions for each give nine combinations ($6 \times 9 = 54$).

On the whole, when we make use of two pairs of discs we have 54 different signals, visible from far in a very distinct way.

Now, in Holland, the upper outer discs are to represent the barometer-height at Helder, Groningen, and the under outer discs the barometer-height at Flushing and Maestricht, and these form at the same time the direction of the expected wind. They show the azimuth of the gradient (the strike). The two inner discs denote the magnitude of the gradient (the fall).

All these positions are to be seen in the joined diagrams.

3135a. Gauss's Heliotrope, ancient construction.

3135b. Gauss's Heliotrope, modern construction.

Both instruments were constructed in the years 1821 and 1822.

Geodetic Institute of the Observatory at Göttingen, Prof. Dr. Schering.

3135c. Heliotrope, an instrument for throwing the reflected light of the sun in any required direction.

Prof. W. H. Miller, M.A., F.R.S.

The Heliotrope consists of a plane glass mirror, two adjacent edges of which are ground and polished in planes making right angles with one another and with the large planes of the mirror, and then covered with asphaltum varnish. A portion of the silvering, not larger than the pupil of the observer's eye, is removed from the angle where the two small polished surfaces meet the hinder plane of the mirror.

...uch a position that the sun's light falls in the solid angle ...ce of the mirror and the two small polished surfaces, a portion ...ght that falls upon the face of the mirror is refracted at the ...ace, reflected internally at each of the small surfaces, and finally ...ges through the space from which the silver has been removed, in a ...tion parallel to, but opposite to, that in which the reflected light travels ...the large plane of the mirror.

...nce, any point with which the faint image of the sun appears to coincide will receive the light of the sun reflected from the mirror.

3136. Sun Signals, fo... ...e of travellers.

Francis Galton, F.R.S.

The difficulty in sun-signalling ... ...ect the flash aright. The rays of the sun are reflected from a mirr... ...ne of light precisely similar to that which reaches it, the mirror itself ... ...se may be disregarded) being the ... of the latter cone, and the sun's ... its base. It follows that to the ...ller, whose eye is near the mirror ... place where the cone of reflected ...falls on the distant landscape wou... ...lways appear to him as a disc of precisely the same shape and size a... ...e sun itself. In other words, his accuracy of aim must be within 30 ... ...tes of a degree. In the author's heliostat an image of the sun is prod... ...which overlies the area on which the flash of the mirror falls. A lens ... ...d in the instrument at right angles to the line of sight; half of the lens ... ...within the tube through which the observer looks, and occupies a portion of his field of view, the other half is external to his field of view; it projects beyond the side of the eye tube, and receives the flash of the mirror. The mirror turns on an axis attached to the tube, which allows it movement in one direction, while the rotation of the entire instrument in the hand gives movement in the other. When the mirror is so adjusted that the reflected (parallel) rays from any one point of the sun's disc impinge on the lens, they are brought to a focus on the screen, and form a minute speck of light upon it. Rays radiate from this speck in all directions, and those that strike the part of the lens inside the eye tube are reduced by its means back again to parallelism with the rays that originally left the mirror. Consequently the eye, looking down the tube, sees a bright speck through the lens, which it refers to the same distant point in the landscape seen to the side of it as that to which the unobstructed rays from the mirror are being flashed. If a telescope be fitted to the tube the speck would overlie the spot on the landscape. Now what is true for any one point in the sun's disc is true for every point, therefore the signaller sees a luminous disc in his field of view, and this exactly overlies the *locus* of the flash. By gently rotating the hand the image can be made to cover or to forsake any point in the landscape that may be desired, and when that is done an observer stationed at that point will see a succession of flashes. Morse's alphabet can be adopted. A flash passing through a square hole of only one-third of an inch in the side is visible to the naked eye at a distance of 10 miles, if the background be dull and the air perfectly clear.

3137. Optical Telegraph, by Colonel Laussédot, composed of a transmutor and of a receiver, with their stands.

Colonel Laussédot, Paris.

3138. Models illustrating two methods of **verifying Sextants** employed at the Kew Observatory:—

1st. By flashing the sun's rays to distant mirrors, whereby stars of light were visible to the operator at the testing table.

This was ceased to be employed on account of the rarity of sunshine. Designed by F. Galton, Esq., F.R.S.

2nd. A system of five collimators, fixed firmly to a wall on a circular arc, arranged so as to send parallel rays across the testing table at known angles. Designed and constructed by J. Cooke, and described in the Proceedings of the Royal Society, vol. XVI., page 2.

Kew Committee of the Royal Society, Kew Observatory.

3139. Spectacles for **Divers,** for use in water.
Francis Galton, F.R.S.

When we look down into still clear water we see all objects in it with perfect distinctness, but on bending down the head with the eyes open, the moment that they touch the water all distinctness of vision ceases. The convex surface of the eyeball has indented the plane surface of the water with a plano-concave lens, and, if we desire to restore distinctness of vision, we must use convex glasses of sufficient power, when immersed in water, to neutralise this effect. A double convex flint glass, each of whose surfaces has a radius of about half an inch, is therefore required. By means of the glasses exhibited it is possible to read the smallest type under water, with perfect ease. The principle of these glasses was described in a memoir read before the British Association in 1865.

3140. Ground Tongs for **Sea Soundings;** invented by Francis Hopfgartner, Austrian Imperial and Royal Naval Officer of the line. *Lieut. Hopfgartner.*

A hole is bored lengthways through the centre of an ordinary plummet. In this hole is inserted a movable metal rail, at the lower end of which there are attached two ladles or spoons, opening and closing by means of a hinge or link. At the upper end there are two movable bows which are joined to the ladles by small chains. If the plumb-lead is suspended to these hook-like bows by means of two short auxiliary lines, the ladles are opened and the apparatus is then ready to be let down into the water. On reaching the ground the bows will fall back, dropping the auxiliary lines, the weight of the lead presses the ladles into the ground, and by pulling up the main plumb-line, which is now acting directly on the metal rail, the ladles are closed and drawn into the hole of the lead so far as to be securely closed.

3141. Ground Tongs for **Sea Soundings,** with dropping weight; invented by Francis Hopfgartner, Austrian Imperial and Royal Naval Officer of the Line. *Lieut. Hopfgartner.*

Two ladles or spoons, intended for securing specimens of the sea bottom, are opened and closed like a pair of tongs by means of two levers. A peculiar metal cover, in which the ladles will fit, secures the closing of the same. At the upper ends of the two limbs of the tongs there are two hook-like movable bows, on which the lead is placed, which, on the apparatus being let down into the water, keeps the ladles in an open position. On reaching the ground the bows will drop back, the weight (stone or a ball) will fall off, and the metal cover will encase the ladles, and keep them closed while the apparatus is being pulled up.

'ew Lead for Deep-sea Soundings; invented by ... Hopfgartner, Austrian Imperial and Royal Naval Officer ...he Line, and Moritz Arzberger, Civil Engineer at Vienna.
Lieut. Hopfgartner and Moritz Arzberger.

The exterior form of this apparatus is that of a tube, of which the lower part forms the contrivance for throwing off the weight, while the centre part contains the indicating apparatus, being a system of metal cases which, through the pressure produced on them by the water, indicate the depth on a scale. The upper part is an arrangement for propelling the apparatus upwards in case the lead is to be used without a line.

...142a. Sinker and Tu... Detaching Appliance for ...William Thomson ...noforte Wire Sounding ...paratus. *Sir William Thomson, F.R.S.*

The pianoforte wire (No. 22 B.W.G. ...ebster and Horsfall's) weighs about 14½ lbs. per nautical mile (6,086 feet ...r, or 12½ lbs. in water.

The strength of this wire to resist ...s such that it bears about 230 lbs. (104 kilogrammes) weight in air, or ...ilometres (or 15·9 nautical miles of its own length).

The splice, a specimen of which is shown, is made as follows —The two pieces of wire to be spliced are first prepared by warming them slightly, and melting and coating of marine glue to promote surface friction. About three feet of the ends so prepared are laid together and held between the finger and thumb at the middle of the portions thus overlapping. Then the free foot and a half of wire on one side is bent close along the other in a long spiral, with a lay of about one turn per inch, and the same is done for the free foot and a half of wire on the other side. The ends are then served firmly round with twine, and the splice is complete.

To the lower end of the wire a ring weighing about ½ lb. is attached, and a chain of two fathoms long, weighing 3 lbs., is shackled to this ring. The lower end of this chain bears an elastic wire double claw. The weight is spherical, with a perforation for the tube and two indentations for the two claws, by which it is hung till it reaches the bottom. The moment its weight is taken off by the bottom and removed from the claws, they spring out and leave it free; but before this is done it presses the tube into the ground by means of a bolt attached to the tube. This bolt is kept by a slight spring in its place until the wire is hauled up. During the time the wire is going down, the tube is kept from falling by this bolt, which after the tube touches the bottom, presses it downwards into the mud. When the wire is hauled up, a piece of small cord two or three inches long, connecting the lower end of the chain with a lever arm belonging to the bolt, which was loose so long as the weight hung by the claws, becomes tightened and draws out the bolt. This leaves the tube free to come away from the weight, and it is drawn up by the cord, chain, and wire.

Two specimens of the apparatus are exhibited, one showing the weight hanging on the claw with the tube resting on the bolt just before touching the ground; the other showing the weight supported partly by the bottom and partly by the tube pressed into the bottom supposed to be mud, and the cord scarcely yet tightened enough to draw out the bolt.

3142a. Ship's Sounders. *L. Casella*

3143. A Registering Water-mark, of new construction, which records the curve of the water-level and its mean height.

Lieutenant-General Baeyer, President of the Geodetic Institute at Berlin.

Invented by the civil engineer, F. H. Reitz, of Hamburg. The apparatus was made in the factory of Pape and Dennert. The clockwork is by Knoblich.

3144. Deep-sea Water-raising Apparatus, according to Dr. Meyer.

A similar one, according to Prof. Dr. Jakobsen.

Ministerial Commission for the Scientific Examination of the German Seas, at Kiel.

Is intended to bring up with certainty a sample of water from any depth in the sea.

3146. Deep-sea Water-raising Apparatus.

L. Steger, Kiel.

3147. Map Drawing Instrument. *A. Bonsack, Berlin.*

Instruments of this kind have come into use in the province of Schleswig-Holstein.

3148. Coast Station Areometer Case.

Ministerial Commission for the Scientific Examination of the German Seas, at Kiel.

The Station Areometer Case gives the specific gravity of sea water against water of + 14° R. within 0·0001.

3149. Two Sets of Ship Areometer Cases, for oceanic voyages.

Ministerial Commission for the Scientific Examination of the German Seas, at Kiel.

The Ship Areometer Cases give about half as accurate results as the preceding; they are characterised by their shortness, which renders their manipulation more convenient on board ship.

3150. Two of the same sort, for voyages in the east part of the Baltic.

Ministerial Commission for the Scientific Examination of the German Seas, at Kiel.

3151. Two Levels, sensitive to turn by $\frac{1}{20}$ to the inch constant from or in any part in the length. *Adam Hilger.*

These levels were made at the desire of the late Colonel Strange, F.R.S., to stand a hot climate like India, and which can be easily filled with ether.

The glass tubes are 9½ ins. long by ¾ ins. in diameter and ground to a radius of 1,000 feet. The ends of the tube have glass plates, which are spherically ground and very highly polished, and fit so accurately that no ether can escape, the ends being kept in their places by a spring which has three arms. The ends of the brass mounts have bayonet joints, so that the level can easily be refilled.

IV.—COMPASSES.

THREE DIFFERENT SIZES (4-INCH, 6-INCH, 8-INCH, OF MARINER'S COMPASS, WITH SUN AND STAR MIRROR, AND BINNACLE CONTAINING CORRECTORS RANTAL SEMICIRCULAR AND HEELING ERRORS.

Sir William Thomson.

—**Binnacle,** with correctors for quadrantal semi- eeling errors, with mirror azimuth instrument on bearings of sun, stars, or terrestrial objects. Small -inch card), suitable for armour-clads or other ships, l error exceeding 11°.

—**6-inch Compass Card,** suitable when quad- rom 7° to 11°.

.—**Medium size (8-inch card)** suitable for ring compass in any ship, iron or wooden, steam or quadrantal error less than 7°.

—**Large size (10-inch card)** suitable for stan- hen quadrantal error does not exceed 5°.

ents here illustrated the object primarily aimed at was to to which the Astronomer Royal's correctors could be and convenience. The quadrantal correctors must not be of the compass as to sensibly affect its direction through he soft iron by the influence of the needles, otherwise the ill, if truly corrected in middle latitudes, be over corrected latitudes, and under corrected in low magnetic latitudes. inch iron cylinders of the Liverpool Compass Committee eir ends at a distance of 7 inches from the centre of an card in this country, they correct a quadrantal error of 7½° is due to magnetization of the iron by the compass the remainder or 5° is genuine, that is to say, dependant on of the correctors by the terrestrial magnetic force. Blocks many tons would be necessary to safely correct for all lati- l error of even so moderate an amount as 5° or 6°, when the re of so great magnetic moment as those of the Admiralty But if, as in the several sizes of compass now exhibited, thin steel wire from an inch and three quarters to three adrantal error of any amount not exceeding 21° may be cor- n all latitudes by a couple of globes of iron of not more than r fixed on two sides of the compass.

quadrantal error of 21½° a couple of globes, each 6 inches in n the two sides of the binnacle at a distance of 6 inches used, with the bearing point of the compass midway between o allow room for the case containing the compass, and for porting it, the diameter of the compass card must not be more). This is the smallest of the four sizes now exhibited.

adrantal error is 11° the globes, if of 6 inches diameter, must es asunder and the 6 inches diameter compass card (II.) may h the same size of globes the distance asunder is 12 inches,

the quadrantal error corrected is $6\frac{1}{4}°$, and, therefore, when the quadrantal error is of this amount or anything less the 6-inch card (III.) may be used.

The binnacle exhibited is suitable for 4-inch or 6-inch compass cards. It contains two adjustable magnetic correctors for the semicircular error, one for neutralizing the athwart ship component, the other the fore and aft component of the ship's magnetic force. The athwart ship corrector suffices to correct an error of about 23°, whether to port or to starboard, when the ship's head is north or south, the fore and aft corrector corrects an error of like amount when the ship's head is east or west. The binnacle also contains, in the four edges of its square top, provision for [illegible]ing securely a pair of bar magnets athwart ship and another pair fore [illegible]t in convenient positions a little below the level of the compass card [illegible]rmer pair to be used when the athwart ship component of the ship's m[illegible] force, the latter when its fore and aft component exceeds the amount [illegible]lisable by one or other of the adjustable correctors. Thus the bin[illegible]ith its several appliances now exhibited supplies convenient means f[illegible]ughly carrying out the complete system of compass correction set for[illegible]e Astronomer Royal in his paper on the correction of the compass, pu[illegible] in the Transactions of the *Royal Society* for 1889, according to the f[illegible]g very simple rule in three parts, as follows :—

I. Place the ship's head north or south [illegible]agnetic and bring the compass to point correctly by the athwart ship [illegible]rrecting magnets.

II Place the ship's head east or west and bring the compass to point correctly by the fore and aft correcting magnets.

III Place the ship's head N.E., or S.E., or N.W., or S.W., and bring the compass to point correctly by the quadrantal correctors (a pair of 6-inch globes now recommended).

The whole process may be thoroughly performed with all needful accuracy for a new ship in a quarter of an hour; though of course it will be desirable to take an hour or two for verifying or perfecting the correction by testing it on other points than the three on which it was first made. When the quadrantal correctors have been once accurately placed they have never again to be changed for the same ship, and the same place in it (except of course in the case of taking on board a cargo of iron or introducing or shifting masses of iron so near the compass as to sensibly modify the quadrantal error). At any time afterwards the semicircular error (which is always liable to change through changes of the ship's sub-permanent magnetism, and also through change of magnetic latitude in the course of a voyage) is readily annulled by placing her head north or south and using the athwart ship corrector, and again east or west, and using the fore and aft corrector. In a steamer this may be done at sea on any clear enough night to allow stars to be seen, or day when the sun's altitude does not exceed 50°. When the weather is moderate enough to allow her to be steered steadily for two or three minutes first on one and then on the other of the two cardinal points nearest to her course, the detention at worst (that is, when the course is on one of the cardinal points) need not exceed five minutes.

The binnacle also contains an appliance for an adjustable magnet below the compass in a line through its centre perpendicular to the deck, for correcting the heeling error in iron sailing ships.

Each magnet supplied for this purpose is in two parts, joined together by a hinge, so that when out of use they cannot be placed in the box provided for containing them without folding them together with unlike poles close one to the other, so that wherever they may be placed in the ship, they cannot disturb any of the compasses. A stout bar magnet brought carelessly on board a ship without this precaution may be as dangerous as dynamite.

An important objection had weighed with the Compass Department of the British Admiralty against the use of quadrantal correctors in the navy. It was, that they would obstruct the taking of bearings of celestial or terrestrial objects for the purpose of correcting the compass or of terrestrial objects for the navigational use of it. On this account the mirror azimuth instrument now exhibited was designed. It not only does away with that objection to the application of quadrantal correctors, but it is much more convenient for ordinary use at sea than the prismatic arrangement hitherto in use. It facilitates very much the taking of star azimuths by throwing (as in the *camera lucida*) an image of the star upon the divided circle of the compass card, illuminated by the ordinary binnacle lamp), or more properly speaking, on a virtual image of this scale at an infinite distance as seen through a convex lens. It is easy when there is not much motion in the ship to read the positions of the star accurately to a small fraction of the white space between two dark degree divisions on which its image is seen. The focal length of the convex lens is a little greater than the radius of the circle, and thus for objects on the horizon or at any altitude not exceeding 30°, no farther adjustment of the azimuth appliance than just to bring the object fairly into the field of view is necessary.

The compass consists of a light aluminium boss, with a central sapphire cap (by which the compass is supported on an iridium point), and a rim of aluminium of from 4 to 10 inches diameter, according to the size of the compass. There is an even number of holes in the rim, and half that number in the circumference of the boss. The rim and boss are connected together by means of fine silk threads forming, as it were, 32 spokes, and the compass-card is partly supported by these threads and partly by the rim. Two or four small magnets having their corresponding ends tied together by silk threads of equal lengths, so that the magnets may be as nearly parallel as possible, are attached to the rim by means of four silk threads.

The compass thus obtained, being extremely light, and having a large radius of gyration, has very small frictional error, with small enough magnetic movement to give a very long period of free vibration. The smallest compass (I.) has just about the same period of free oscillation as the Admiralty standard compass, and the same quality of steadiness at sea, while the larger sizes have considerably longer periods of from 28 to 43 seconds, and therefore much greater steadiness at sea.

3145aa. Marine Equatorial for **correcting Compass** by the **Sun.**

Sir William Thomson, Professor of Natural Philosophy, The University, Glasgow.

A circle corresponding to the earth's equator is set upon gimbals with adjustment, by which the inclination of the circle to the vertical is made equal to the latitude of the place. A lens is mounted in a doubly-pivotted frame, which keeps its centre on the centre of the equatorial circle while allowing the lens to turn round its own diameters through this point.

3151. Azimuth Compass, by Brauer.

T. Brauer, St. Petersburg.

2151a. COMPASSES, ADMIRALTY PATTERN, IN USE IN HER MAJESTY'S NAVY.

EXHIBITED BY THE ADMIRALTY—HYDROGRAPHIC DEPARTMENT.

Admiralty Standard Compass. Tripod; azimuth circle; light and heavy cards; spare cap and pivots. Used for steering and taking bearings.

Plain glass cover when the compass is used for steering. Cover and azimuth circle, for taking bearings, with the card read with a prism, and graduated for measuring horizontal angles. Light card, four compound needles of two laminæ each; ruby cap; pivots two of hard steel, two pointed with native alloy. Heavy card, four compound needles, two of four laminæ, two of two laminæ, cap of speculum metal; pivots pointed with ruby. Tripod and spring, for use of compass on shore.

This compass can be allowed to rest on india-rubber suspension, by turning the screws marked F and A; it has the effect of steadying the card when the compass is exposed to vibration.

Prismatic Azimuth Compass, with tripod, card, spare cap, and pivots. Used for taking bearings on shore, and as a standard compass for small vessels. Card with two compound needles, of two laminæ each; agate cap; pivots of hard steel. Tripod for use on shore.

Steering Compass, large size; with card and spare pivot. For large vessels, card with four compound needles of two laminæ each; cap of speculum metal; pivot pointed with ruby.

Steering Compass, small size, with card, spare cap and pivots. For small vessels. Card with two single needles; cap of agate; pivots of hard steel.

Dent's Liquid Steering Compass. For use when the card of the ordinary compass becomes unsteady.

Liquid, two thirds water, one third alcohol. Air chamber round upper rim, to allow for the expansion of the fluid from temperature; aperture for filling when fluid has wasted. Lifter for raising the card off its pivot when required.

West's Liquid Steering Compass.

Liquid, of same composition as Dent's. Bowl hermetically sealed, the expansion of the liquid being provided for by having the bottom of the bowl made of flexible corrugated metal.

Boat's Liquid Compass, in binnacle, with lamp. For use in boats.

Construction, the same as Dent's Liquid Steering Compass.

Life-boat Compass, in binnacle, with lamp. For use in life-boats.

Construction, the same as Dent's Liquid Steering Compass.

Sledge Compass. Used in Franklin's search-expedition (1850–53).

Card with single needle capable of being moved round under the card, according to the magnetic variation, so that the North on the card coincides with the true North. A light needle in case attached to shoulder strap, for use without card when the horizontal force is weak. Spare card in cover, and directions for use.

Sledge Compass, as furnished to Arctic expedition (1875).

Card with single needle capable of being adjusted to the meridian. Aperture in leather, so that line of direction may be seen without opening cover. Ivory lifter.

Small Azimuth Compass, as furnished to Arctic expedition (1875). For determining the variation of the compass.

Single needle; alloy pivot; ruby cap; graduated circle of alumina metal; sight-vane, and prism.

3151b. MARINERS' COMPASSES OF VARIOUS DATES AND PATTERNS: GENERALLY OBSOLETE.

EXHIBITED BY THE ADMIRALTY—HYDROGRAPHIC DEPARTMENT.

Chinese Compass. Very small needle resting on steel pivot; cover of talc.

Walker's Meridional Compass; with apparatus for determining the latitude when the sun is on the meridian, also the sun's altitude, and hour angle.

Crow's Liquid Compass (Patent 1813).

Card hollow, convex lens shaped, buoyant and pressing upwards against the pivot. Expansion of liquid provided for by air chamber round upper rim of bowl; also by a spring valve allowing the escape of expended air and refilling when required. In the original patent the liquid was entirely alcohol.

Pope's Dipping Needle Compass (Patent 1820); with arc showing dip of the needle.

Graydon's Celestial Compass (Patent 1824); with apparatus for determining the latitude, the angular distance between celestial objects, and their true azimuth.

Danish Azimuth Compass; with telescope for observing distant bearings.

Steering Compass, by Sir William Snow Harris (about 1831); with stout copper ring, to calm vibrations of needle.

Liquid Compass. A steering compass; same ..s Dent's without air chamber.

Dent's Axis Compass (Patent 1844). Card with four heavy and deep needles, attached to axis working in socket above and below, preserving card parallel to surface.

Steering Compass, by Captain Walker, R.N. Card with single needle, centre of gravity below point of suspension; pivot long and on a brass bell-shaped cap, the latter cap working also on a pivot.

Grey's Vertical [illegible] ent 1854). Liquid between outer and inner bowls; ca[illegible] two dipping needles; pivot inverted.

Gowland's Liquid C[illegible] Patent 1854). Rim of card vertical; pair of needles; pivo[illegible]erted.

Compass by Mr. Keen (Patent 1854). Porcelain bowl; card two single needles; pivot on springs inverted; cap centred in india rubber ring.

Magnets used, in correcting ship's compasses. Hardsteel; 6 inch; 10 inch; and 12 inch.

3151d. Floating Mariner's Compass.
Dumoulin Froment, Paris.

3151e. Eclimétre for floating compass forming a spherical spirit level for quick elevation. *Dumoulin Froment, Paris.*

3151i. Albini's Registering Steering Compass.
Elliott Brothers.

The instrument consists of a steering compass, with clock and apparatus attached, for printing on a slip of paper the direction of the ship's course every five minutes, the clock giving the exact time for eight days without winding. An instrument of this description placed in the captain's cabin would thus enable him to have a record of a whole voyage.

3151k. Dipping Needle and Compass used by Captain Cook during his voyage round the world.
Royal Naval Museum, Greenwich.

3151l. Chinese Compass, from a collection made by Mr. Coryton, Barrister-at-law of the Temple.
Royal Naval Museum, Greenwich.

3151m. Symon's Compasses. *L. Casella.*

3151n. Coloured Compass Cards. *Max. Raphael, Breslau.*

3151o. Mica-plates for uncoloured **Compass Cards.** *Max. Raphael, Breslau.*

For the manufacture of compass cards, mica is now exclusively used. The advantage to be derived from its use consists in the greater facility with which the magnetic needle can be fixed, the transparency of the card, its non-conductivity for electricity, its lightness and indifference to ordinary changes of temperature, its durability, &c.

3151p. Compass, Hart's. *M. Bréguet, Paris.*

3151q. Patent True Course Finder. *W. H. Roberts.*

The object of this instrument is to avoid arithmetical calculation in finding the true course from the compass or magnetic course, with corrections for lee-way, deviation, and variation. This instrument will give by three movements of the index the true course to fifteen minutes. The outer rim of the dial is accurately divided into degrees, and the inner rim into points, ½ points, and ¼ points. The index has two arcs, A and B, and moves freely on a pivot, C. The arc A indicates the points, ½ points, and ¼ points. The arc B is so made that its centre line will point to the exact number of degrees which are contained in the number of points shown by the arc A. The arc B has also a vernier, by which the observer can read off to ¼ of a degree. On the extreme inner rim are arrows, half encircling the dial, to remind the observer in which direction to allow easterly and westerly deviation and variation.

3151x. Chinese Compass. *Ministry of Marine, Madrid.*

This differs from those employed by other nations, in the inversion of the meridian line.

3151y. A Compass or Azimuthal Needle, which was employed in making the plans of the coast. This instrument was made at Carthagena, at the end of the last century. *Ministry of Marine, Madrid.*

3151z. Compass made at Carthagena, Spain, according to the plan adopted by Don Antoino Doral, the Commander of Fleet. *Ministry of Marine, Madrid.*

V.—MAPS, BOOKS, &c.

COLLECTION OF MAPS, &c., LENT BY THE ORDNANCE SURVEY. MAJOR-GENERAL CAMERON, R.E., C.B., F.R.S., DIRECTOR-GENERAL.

MOUNTED MAP of part of the city of WINCHESTER, scale $\frac{1}{500}$, or 10·56 feet to one mile, with corresponding photographic reduction on $\frac{1}{2500}$ scale from MS. plan.

MOUNTED MAP of part of LONDON, scale 5 feet to one mile.

[M]AP of SOUTHAMPTON and its environs, scale $\frac{1}{2500}$, or [2]5 to one mile.

[MO]UNTED MAP of part of HAMPSHIRE around Southampton, [scale] 6 inches to one mile.

MOUNTED MAP of part of SCOTLAND (in outline), scale 1 inch to one mile.

MOUNTED MAP of part of SCOTLAND (hill features engraved), scale 1 inch to one mile.

MOUNTED MAP of JERUS[ALEM, sho]wing the hill features, scale $\frac{1}{2500}$, or 25·344 inches to o[ne mile].

PORTFOLIO, containing spe[cimens] of MAPS of TOWNS on the $\frac{1}{500}$ scale and 5 feet scale, viz.

$\frac{1}{500}$ scale, zincographed.

Cheshire, Chester, Sheets XX[X]VIII, 11, 17, 18; XXXVIII. 15, 2.

Cheshire, Hyde, Sheet XI, 1, 19.

„ Crewe, Sheet LVI, 7, 10.

Kent, Canterbury, Sheet XLVI, 3, 14.

Sussex, Chichester, Sheet LXI, 7, 16, 17, 21, 22.

Gloucester, Cirencester, Sheet LI, 10, 10. With shading of houses transferred to zinc from lines engraved on a copper plate.

Gloucester, Cirencester, Sheet LI, 11, 6. With shading of houses transferred to zinc from lines engraved on a copper plate.

5 feet scale, engraved.

London, Sheets VI, 30.

„ „ VII, 53, 56, 64, 65, 66, 73, 76, 77.

„ „ VIII, 12, 31, 41, 61, 71.

PORTFOLIO, containing specimens of MAPS of the CADASTRAL SURVEY on the $\frac{1}{2500}$ scale, or 25·344 inches to a mile, approximately 1 square inch to an acre, viz.:—

London, Sheets XLII, LXV, LXXIV, LXXV.
Denbigh, Llangollen, Sheet XXXIV, 15.
Cheshire, Chester, Sheet XXXVIII, 11.
Hants, Winchester, Sheet XLI, 13.
Kent, Canterbury, Sheet XLVI, 3.
„ Dover, Sheet XLVIII, 14.
Sussex, Rye, Sheet XLV, 7.
Forfar, Dundee, Sheet LIV, 5.

Lanark, Hamilton, Sheet XVII, 4.

Essex, Chigwell parish, Sheets LVII, 15 and 16; LVIII, 9, 13, 14; LXV, 3, 4, 7, 8; LXVI, 1, 2, 5, 6.

One book of areas of Chigwell parish.

Sheets of London reduced by photography from the 5 feet scale to the $\frac{1}{2500}$ scale, or 25·344 inches to one mile.

Sheets VII, 3, 13, 14, 23, 24, 73, 83, 93.

Photographic reduction used in producing the Cadastral Map on the $\frac{1}{2500}$ scale from the Town Map on the $\frac{1}{500}$ scale.

Sheets LXI, 7, 6, 7, 11, 12, 16, 17, city of Chichester.

PORTFOLIO containing specimens of COUNTY MAPS on the scale of 6 inches to one mile, viz.:—

Hants, Sheet XLI, LXV.
Kent, Sheets VII, XLII.
Middlesex, Sheets VII, XI, XVI, XXI.
Surrey, Sheets VII, VIII, XIV, XXIII, XXIV, XXV.
Aberdeen, Sheet LXXV.
Argyll, Sheets XCVIII, CXLIX, CLXXIX, CXC.
Bute, Sheet CCIV.
Dublin, Sheet XVIII.

Surrey, Sheet XVI. Reduced by photography from the $\frac{1}{2500}$ scale to the 6-inch scale and photo-zincographed.

Hampshire, Sheet LXXII. With a reduction to the 3-inch scale by photo-zincography.

Hampshire, Sheet LXXX. With a reduction to the 3-inch scale by photo-zincography.

12 mounted photographs reduced from MSS. plans on the $\frac{1}{2500}$ scale, or 25·354 inches to one mile, to the $\frac{1}{10560}$ scale, or 6 inches to one mile, by photography.

Photographic reductions used in producing the County Map on the scale of 6 inches to a mile ($\frac{1}{10560}$) from the MSS. sheets of the Cadastral Map. Scale, 25·344 inches to a mile ($\frac{1}{2500}$), viz:—

Essex, Sheets XLV, 10, 12; LX, 5.
Hants, Sheet VIII, 8.
Shropshire, Sheet XIII, 2.
Sussex, Sheet XXI, 16.

Map of the Turco-Persian frontier; made by Russian and English officers in the years 1849 to 1855, on the scale of $\frac{1}{73050}$, and reduced to the scale of $\frac{1}{253440}$, or four English miles to 1 inch, at the Ordnance Survey Office, Southampton. Drawn on Sir Henry James's Rectangular Tangential Projection of the Sphere; and photo-zincographed at the Ordnance Survey Office, Southampton, 1873.

PORTFOLIO, containing specimens of MAPS on the 1-inch scale, viz.:—

Geological Survey. England, Sheets XCII, S.W.; XCVIII, S.E.; CV, S.W.

Reconnaissance survey of the Sea of Galilee and vicinity, by Captain Anderson, R.E.

Details of temples, &c., in the neighbourhood of Mount Hermon, by Captain Warren, R.E.

Reconnaissance survey of the Jordan Valley and neighbourhood, by Captain Warren, R.E.

MAPS EXHIBITED BY THE ORDNANCE SURVEY DEPARTMENT OF THE ROYAL PRUSSIAN GENERAL STAFF, BERLIN.

3152. A Copy of an Original Survey taken by means of Surveyor's Table.

Map B. 1. Nine surveyor's table sheets, north-west from Berlin, according to the original survey in $\frac{1}{25000}$, lithographed, with mountain features, marked in lines.

Map B. 2. The same country district, in $\frac{1}{50000}$.

Map B. 3. The same country district, copper plate, in $\frac{1}{100000}$.

Map B. 1. Eastern Prussia composed of the sections of the Ordnance Map of the General Staff, copper plate print, in $\frac{1}{100000}$, northern part.

Map C. 2. The same province, southern part.

Map D. The western part of the province Hesse-Nassau, copper plate, in $\frac{1}{100000}$.

Map E. Environs of Berlin, copper plate print, in $\frac{1}{100000}$, with illuminated watercourses, meadows, and villages.

The maps Nos. 1–4 (or A1, B1 to 3) represent the process from the field-work to the publication of the maps on three different scales, namely, $\frac{1}{25000}$ (original survey); $\frac{1}{50000}$, and $\frac{1}{100000}$. The last is specially intended for military purposes.

The maps C1, C2, and D, show larger surfaces, the two former in hilly, the latter in mountainous country. On copper in $\frac{1}{100000}$.

The map E represents a surface of 70 geographical square miles in level country. On copper in $\frac{1}{100000}$, with the water, meadows, and districts coloured.

SECRETARY OF STATE FOR INDIA.

3153. Selection of Maps to illustrate the progress of **Cartography and Surveys in India.**

The Secretary of State for India.

(1.) Fortelezas do Mombaim e Ilha de Carania.

Old Portuguese plans of Bombay and Karanja, extracted from the "Livro de Antonio Bocarro, Guardamor de Archivo Real da India," &c., 1646. (Bombay was ceded to England in 1661, and became the seat of the presidency in 1683. The Portuguese retained the Island of Karanja in the harbour of Bombay until it was seized by the Mahrattas in 1683. In 1774 Karanja was taken by the English.)

(2.) A Dutch chart of the Deccan (properly Concan) and Malabar Coasts, with the Laccadive and Maldive Islands and the

Padua Bank, &c., including the western coast of India from Diu to Cape Comorin and part of the Gulf of Manaar, with soundings. Date, 18th century. MS. (No. 227).

A Dutch chart of the Malabar Coast and Backwaters, from Coilang (Quilon) to Cranganor, with soundings. By Jan Tim, revised by H. G. Farrant, Engineer. Date, 1697. MS. (No. 229).

A Dutch chart of the coast of Coromandel, from Toady to Point Goddewarre (Godavery). Also a chart of the coast of Orissa. MS. (No. 254).

These are selected from a series of MSS., the originals of which are in the State Archives at the Hague, and catalogued in the "Inventaris der Verzameling Karten berustende in het Rijks Archief," 2 vols., 8vo.

(3.) A collection of Dalrymple's charts in 1 vol.

(4.) A Bengal atlas, containing maps of the theatre of war and commerce on that side Hindoostan, compiled from the original surveys, and published by order of the Honourable the Court of Directors for the affairs of the East Indian Company, by James Rennell, F.R.S., late Major of Engineers and Surveyor-General in Bengal, 1781. (Second edition.) 21 maps, folio, bound.

(5.) Rennell's map of India.

(6.) Geographical and statistical map of the north-east part of the Mysore dominion or the ceded districts, &c. By Colin Mackenzie, Surveyor-General of India, 1815. Scale, 4 miles to 1 inch; size, 59 inches by 74. MS.

(7.) Topographical survey of Madras and its environs, by the Officers of the senior class of the Military Institution, 1806. Scale, 2 inches to 1 mile; size, 78 inches by 49. MS.

(8.) Mullangoor Circar, surveyed in 1834, on 15 small sections. MS.

(9.) Map of Mullangoor Circar, executed under the superintendence of Lieut. H. Du Vernet in the year 1834. Lithographed by Trel. Saunders.

(10.) Survey of the River Ganges from Hurdwar to Nahgul, taken in the month of February 1800, under the immediate instructions of Major-General Sir James H. Craig, K.B., &c. By Lieut. Thomas Wood, Corps of Engineers. Part 1. Size, 51 inches by 21. MS.

The survey is complete in 7 parts.

(11.) Survey to Gangotri, by Lieut. Webb, 1810. The general map scale, 24 miles to 1 inch. MS.

The survey on the scale of 1 inch to 1 mile is on 12 sheets.

(12.) . . . . Map of India, compiled from all the latest and

most authentic materials . . . . By A. Arrowsmith. London, 1816.

(13.) Atlas of Southern India, in 18 sheets, from Cape Comorin to the river Kistnah, delineated on a scale of 4 English miles to 1 inch, principally from original surveys communicated by the Honourable Court of Directors of the East Indian Company. By A. Arrowsmith. London, 1822. Folio, half-bound.

(14.) The Indian atlas. The index map and sheets of the Punjab, mounted on roller.

(15.) Chart of the Red Sea, on three sheets. By Captain Moresby.

(16.) An atlas of the North-Western Provinces. Settlement maps compiled and lithographed under the order of H. M. Elliott, Esq., 1840 to 1843. Folio, half-bound.

An atlas of the district maps of the Lower and North-Western Provinces of Bengal, including the second edition of the district maps of the North-Western Provinces. Folio, 2 vols., half-bound.

(17.) Map of the Eastern Frontier of British India, with the adjacent countries extending to Yunan in China. By Captain R. Borleau Pemberton, 44th Regiment Native Infantry, 1838.

(18.) The districts Jhelum, Rawalpindi, and Shahpoor. By Captain D. G. Robinson, Engineers.

A specimen of the drawings.

(19.) The same lithographed on 28 sheets.

(20.) Map of Kashmir, with part of adjacent mountains. By Captain T. G. Montgomerie, Engineers, &c. Scale, 2 miles to 1 inch. On four sheets.

Jamoo, Kashmir, &c. Scale, 4 miles to 1 inch. On four sheets.

(21.) Madras revenue survey :—
Nellore district map.
Bapatla Paluk map.
Kelampakkam village map.

(22.) Revenue surveys :—
District Peshawur, 10 sheets.
Peshawur Cantonment City, &c., four sheets.
District Seebsaugur, Assam, 11 sheets.

Topographical surveys :—
Rewah survey, a selection mounted.

(23, 24.) General map of the Punjab, four sheets.
General map of the North-West Provinces, four sheets.
General map of Assam.

(25.) S. G. O. engravings of Indian atlas.
(26.) Himalayan sheets of Indian atlas.
(27.) Kumaon and Gurwhal, on 37 sheets, a selection mounted together.
(28.) Kattywar survey, a selection mounted together.
(29.) Guzerat survey, the three published sheets.
(30.) Colonel Walker's map of Turkistan, four sheets, mounted together.
(31.) Colonel Montgomerie's Trans-frontier maps.
(32.) Sholapore Collectorate, in a cover.
(33.) Laughton's Bombay, 172 sheets, a selection mounted together.
(34.) Ditto, reduced scale.
(35.) Native explorer's maps of—
Arun River.
Tengri Nor.
Western Nepal.
Rudok.
Sanpu River.
(36.) The Mesopotamian surveys.
(37.) St. John's Persia, six sheets. Beluchistan.
(38.) Prinseps. Atlas of Sealkote district.
(39.) Progress report maps.
(40.) Greenough's geological map of India.
(41.) Geological atlas of India.

3153a. Selection of Maps and Publications to illustrate the progress of **Cartography and Surveys in Spain.**

Istituto Geografico y Estatistico de España.

(1.) Red Geodesica de Primer Orden en 1874.

The actual state of geodesic studies in Spain is represented on a scale of $\frac{1}{2000000}$. The thick black lines mark the triangles in the French and Portuguese net, which is joined to the Spanish; thinner black lines mark the direction of the Spanish system; the black lines of the plan point out the quadrilateral directions or capitals of provinces. The localities of which the latitudes are determined astronomically are marked with a blue semicircle; the localities in which the difference of longitudes is determined are marked with a red semicircle; the azimuths known are marked with a blue circumference. The lines of leveling are traced with red ink, with a continued line those already observed, and by dots those not yet carried out. The localities in which mareographs have been established are marked with a red cross.

(2.) Publications relating to the International Commission on the Metre.

The determination of the metre and international kilogramme is one of the most interesting problems of measurement.

The International Commission assembled to determine this was formed of members of all nations.

In the sessions held at Paris in 1872 this Committee removed all the general doubts relating to the construction and comparison of the international prototypes of weights and measures, and appointed a permanent committee instructed to carry on the work. The Spanish commissioner, Brigadier Ibañer, was named president.

The permanent Commission have spared no efforts to overcome the numerous difficulties presented in the construction of the metre and kilogramme and in the comparison with the metre of the French Archives.

Their efforts have reached as far as the construction of two provisional bars for the metre, and they are now proceeding to melt the irridiated platinum for the metres required.

In the third pamphlet a description is given of the latest experiments.

(3.) Numerical Results of the Levels of Precision taken between Alicante and Madrid, and Madrid and Santander.

The results given are those which have been obtained in the two levelling lines, giving the heights found in all the points of reference and the errors which appear.

(4.) Memoir upon the general compensation of the errors contained in the geodesian net of Spain, by Don Toaquin Barraquer and Don Francisco Cabello, Madrid, 1874.

This memoir is a most important study of geodesy, applied to the net formed by geodesical first class chains, which, following the direction of the meridians, parallels, and coasts, comprehends the Spanish territory of the Peninsula.

The authors of this memoir, by their intimate knowledge of all the theoretical studies published on this subject, have been enabled to give a practical form to the immense work of compensating our net in such a manner that, as they are able to take in the total extent of their undertaking, they can present a rational division with all the scientific conditions required.

(5.) Studies of Geodetic Levelling, by Don Carlos Ibañer, 1 vol., 4to., pl., Madrid, 1864.

The object of the author is to examine the accuracy of the different methods employed up to the present time in geodesical studies to determine the third co-ordinate of the zenith of triangulations, and most especially to apply the practice of geodetic levelling to a theory presented 25 years ago by Biot, which had never been tried in Spain or elsewhere.

(6.) Instructions for Geodesical Studies. 1 vol., 8vo., pl., Madrid, 1872.

This book contains instructions for the observation of angles in geodesical triangles, instructions to carry out the calculations, and instructions for the persons appointed to make these studies.

(7.) Comparison of the Geodetic Standard Bar belonging to the Government of the Viceroy of Egypt with the one which served to measure the central base of the Map of Spain, by Ismail Effendi and Don Carlos Ibañer.

M. Brunner constructed, by order of the Egyptian Government, an apparatus for measuring bases, identical in character with the Spanish model; he tested

order to ascertain its co-efficient of expansion. It was, however, able to determine its length, and to do so the Spanish geodetic ... n.

Ismail ...endi came to Madrid with the Cairo astronomical apparatus; Don Ibañez was appointed for this commission; they both agreed as to the manner of carrying out the operation, and they carried out the observations and calculations until they obtained the equation of the Egyptian bar with a probable error of $\pm 0 \cdot 0011^{mm}$.

A full account of this is given in the book exhibited; the plate representing the comparator mounted at the Observatory of Madrid, to verify the comparison of the Egyptian and Spanish ...

(8.) Plan of Madrid on a scale of $\frac{1}{2000}$.

This plan consists of several sheets engraved on stone.

The plan includes all the apparent details of the capital of Spain, the houses, number of streets, the trees, public and private gardens, and principal buildings.

The sheets are divided into squares, with their corresponding letter and number.

The levels are represented by contours, traced metre distances with the corresponding enumeration of the heights referred to the Mediterranean.

(9.) Memoirs of the Geographical and Statistical Institute of Madrid.

This important work comprehends the result of the goedesian studies between Salamanca and Madrid, terminated as far as the establishment of the interdepending equations between the calculations of every station and those that are required by the compensation of the whole polygonal system, the observations taken at every station, an account of these, the calculations of the most probable directions relating to every isolated station by the establishment of the equations already alluded to, &c.

The second memoir gives an account of the levelling of the line from Alicante to Madrid.

The third memoir describes the determination of latitudes and azimuths, and comprehends the astronomical geodesian studies carried out by the members of the Madrid Observatory for the Geographical Institute, in order to ascertain with proper exactitude the latitudes, longitudes, and azimuths, in a certain number of vertices of the first class net. These studies are carried out by Don Manuel Morino.

This volume contains other papers of high topographical interest.

(10.) Topographical Map of Spain.

The map of Spain on a scale of $\frac{1}{50000}$ is composed of about 1,078 sheets, engraved in five colours, with numerous details. The sheets comprising Madrid, Colmenar, Viejo, and Yetafe are already engraved.

The general plan of the levellings used for Spain (plate 20) comprehend, besides the line of Alicante to Santander, passing by Madrid, other lines which, starting from Madrid run one to the N.E. which is to connect itself in Perpignan with the French lines, another towards the south, which will serve to determine the difference of levels between the observatories of Madrid and St Ferdinand, and other two which starting from Madrid will go to Lisbon and Oporto. The remaining lines will complete this plan, and bring out the levels of the capitals of provinces and towns of importance.

The system of lines is so disposed that it offers numerous polygons in order to establish conditions which may give greater precision to the results.

In conformity with the instructions of the Commission appointed to carry out this map, the levelling of precision will follow in general the roads of communication, as railroads and bye-roads of every description. The levelling will be from the centre and double, carried out by different observers, and with different instruments. The calculations will be taken from Madrid. The greatest error admissible, deduced from a double levelling, is not to exceed 4 millimeters per kilometer, and in general will be less than $5^{mm}\sqrt{R}$, R being the number of kilometers.

The general lines must be divided into independent sections, and these into portions of a kilometer, with benchmarks at the extremities of the section, important towns, &c.

In August 1871, the levelling of the line between Alicante and Madrid was begun; touching Madridejos at its base, 540 kilometers were levelled in 916 days, of which only 451 were useful. The number of stations verified was 11,782.

The line from Santander to Madrid was levelled in 1873 in the same manner, and this will determine the difference of level between the ocean and Mediterranean.

Without taking into account the datum points of the seaport towns, a standard datum has been established irrespective of mean sea level. This point is situated at the observatory of Madrid, although, considering its geological conditions, the hill upon which it is placed does not offer the securities which might be desired. Four others have been placed in different parts of Madrid.

(11.) Experiments made with the Apparatus for Measuring Bases, belonging to the Commission of the Map of Spain. Madrid, 1859.

The authors, Don Carlos Ibañer and Don Frutos Saavedra Meneses, were appointed in 1853 to propose the system of microscopes and bars with which the base of the geodesical net of the Peninsula was to be measured. They went to Paris to superintend the construction of an apparatus of their invention, intrusted to M. Brunner.

This apparatus principally consists of a platinum bar, which forms a metallic thermometer with another of latteen; they both rest on an iron bench placed upon movable supports resting upon wooden tripods. Various micrometric microscopes are placed in the centres of graduated circles fixed in other tripods, and these divide the geodesian base which is to be measured into small intervals, the length of which is determined by placing the bar between every two microscopes, and observing the divisions of the platinum and latteen. An eye-glass and two lenses are used to establish the tripods of the microscopes in the line of the base, and another glass settles the beginning and end of the day's work.

This delicate apparatus cannot be sent out of the country; it is preserved at the Geographical Institute of Madrid, as the type of all lineal metrological and geodesical studies.

After this study was made, the expansion of the bars was investigated and compared with that of Borda, at the Paris Observatory, which has served as the metric type of all the geodesian bases measured in France since 1798.

The result of the studies is given in this work, and the manner of using this apparatus and carrying out the calculations.

These plates represent—

(*a.*) Two of the projections of the bar and level mounted upon its supports

and tripods, and the microscopes placed to observe the lines of division at the extremes.

(*b*.) Represents in detail the construction of the supports of the bar, and slow and quick movements which it is capable of making, the construction of the latteen and platinum bars, the details of the same divided into decimilmeters, and a drawing of the level of the bar.

(*c*.) Details of the micrometric microscopes with movables, circles, reference glass, lenses, and tracers.

(*d*.) Represents the comparator. Experiments to verify the studies of expansion in oil bath.

(*e*.) Same in detail as the former.

(*f*.) This plate represents the implements used by the observers to construct and compare thermometers.

(*g*.) This plate represents Borda's bar with which the Spanish one was compared.

(12.) Geodetical description of the Balearic Islands, by Don Carlos Ibañer. Madrid, 1871.

The author was commissioned in 1864 to study the first of the geodesian Catastralian districts, which are comprehended in the provinces of Castellon, Valencia, Alicante, and Balearic Islands; he verified it in the campaigns of 1865, 1866, 1867, and 1868, and made the necessary studies to describe and interlace the three groups formed by the islands of Tviza and Formentera with surrounding islets, with those of Mallorca, Cabrera, and Dragonera, and with the island of Minorca and adjacent islets. Each of these groups with its corresponding triangulations is divided by first, second, and third class nets.

Each local triangulation was founded upon a base measured by the Ibañer apparatus, constructed by Messrs. Brunner.

In the first part of this work will be found a description of the instruments and accessories employed in this study, beginning with the new apparatus for measuring bases. This consists principally of a plated iron bar, with four thermometers of mercury and a plane table, placed upon tripods and supports, microscopes, and lineation glasses, and reference to the beginning and end of the daily work. This apparatus offers the greatest advantage over other analogous instruments, for the rapidity and ease with which the measures are taken, without losing the degree of exactitude required for a geodesical base. It is to be employed to measure the three bases still wanting in the Spanish geodesian net projected in the provinces of Cadiz and Lugo.

The probable errors resulting from the measurement of the Balearic Islands were—

Base of Ibiya $\pm 0 \cdot 401^{mm}$, or $\pm 0 \cdot 00000240$ of the length measured.

Base of Prat, Mallorca, $\pm 1 \cdot 681^{mm}$, or $\pm 0 \cdot 000000794$ of the measured length.

Base of Mahon (Minorca) $\pm 0 \cdot 770^{mm}$, or $\pm 0 \cdot 000000326$ of the length measured.

The Southampton Institute has made several metrological studies. The apparatus invented by Ibañer, which was connected with the bar constructed by Borda, produced the most satisfactory results.

The three other parts of this work refer to triangulations of the three groups of the above mentioned islands. The plates represent—

(*a*.) Drawing representing the bar of the Ibañer apparatus in two projections, mounted for observation.

(*b*.) Details relating to the supports of the bar and its construction.

(*c*.) Microscopes; glasses and other details of this apparatus.

(*d.*) Form, dimensions, and construction of the station marks given in the vertices of the 1st, 2nd, and 3rd order.
(*e.*) The theodolites employed for the azimuth and zenith observations of 1st class nets of the Balearic Islands.
(*f.*) Represents a theodolite of 2nd class, and the observation tints employed to measure the bases.
(*g.*) Geodesical local nets interlacing the groups of the Balearic Islands. Printed in three colours. The first class net is in black, the 2nd in red, the 3rd in blue.

They prove that in a scale of $\frac{1}{500000}$ in 5 kilometers topographic will always meet with a geodesical vertex perfectly and accurately determined.

(13.) Central base for Geodesical Triangulation in Spain, by Don Carlos Ibañer, Lieut.-Col., &c., Don Frutos Saavidra, Don Fernando Monet, and Don Cesario Quiroga; Madrid, 1865.

The parting line chosen for the geodesian triangulation of Spain starts from the central base of Madridejos (province of Toledo). The direct measure gave a result of $14 \cdot 664^{m}$, $5 \cdot 000 \pm 0 \cdot 0025^{m}$, with a difference of level between the extremes (Bolos y Carbonera) of $2 \cdot 482 \pm 0 \cdot 010^{m}$.

These studies were carried out by the gentlemen mentioned on the title-page of the book, by means of the apparatus of Ibañer.

The measures adopted to fix the extremes of the base, to trace the lineation of its five sections, and establish a trigonometrical net by which it might be determined whether it was necessary or not to measure bases of great extension, are all given in detail in this work. The observations and calculations for the measurement and levelling of the extremes of the base, the triangulating studies and compensation of the net, and the final results of this operation are also mentioned.

The results of these operations, and their precision, may be judged by the probable error of measurement, which has already been mentioned, as $\pm 0 \cdot 0025^{m}$, or $\frac{1}{5800000}$ of the length of the base.

In order to decide the question of the extent of base line requisite, a comparison was made between the direct measure of the sections of the base and their length deduced from the calculations of the trigonometrical net, which gave the following results :—

——	Measure.	Triangulation.	Difference.
	m	m	
First section - -	3077·459	3077·462	−0·003
Second „ - -	2216·397	2216·399	—0·002
Third „ - -	2766·604	2216·399	—0·002
Fourth „ - -	2723·425	2723·422	+0·003
Fifth „ - -	3879·000	3879·002	−0·002
Base - - -	14662·885	14662·889	−0·004

These remarkable results proving the direct measurement, at the same time give authority for reducing the length of the geodesical base to two or three kilometres, that is, whenever they are connected with the sides of the net by means of a system of lines suitable for compensation. This is the first experimental result of the kind given in geodesy.

PLATES.

(a.) Measurement of Madridejos wooden gallery formed of nine moveable houses in which the apparatus was sheltered from sun and wind.

(b.) A plan on scale of $\frac{1}{20000}$ of the country surrounding the base of Madridejos with division in sections.

(c.) Vertical sections of the central base, on a scale of $\frac{1}{20000}$ for horizontal distances, and $\frac{1}{1000}$ for the heights.

3153b. Selection of Maps and Publications to illustrate the progress of the **Geological Survey of Spain.**

Comision del Mapa Geologico de España, Cath. de Isabel la Catolica, 23, Madrid.

(1.) **Junta** general de Estadistica.

Descripcion fisica y geologica de la provincia de Santander, por Don Amalio **Maestre, second** class inspector of the Society of Mining Engineers. 1 vol. **Madrid, 1864.**

(2.) **Junta** general de Estadistica.

Ensayo de Descripcion geognostica de la provincia de Teruel, by Don Juan **Villanova y** Para. 1 vol. Madrid.

(3.) Boletin de la Comision del Mapa geologico de España. Vols. 1 and 2. Madrid, 1874–75.

(4.) Memorias de la Comision del Mapa Geologico de España.

Bosquejo de una descripcion fisica y geologica de la provincia de Zaragoza, by Don Filipe Martin Donayre, first class engineer of the School of Mines. Madrid, 1874.

Descripcion fisica geologica y agrologica de la provincia de Cuenca, by Don Daniel de Cortarjar, mining engineer, and member of the French Geological Society. 1 vol. Madrid, 1871.

Trabajos geognosticos y typograficos practicedos por la Comision de Estudio de la Cuenca Carbonifera de Asturias. Madrid, 1874.

(5.) Mapa geologico de la provincia de Madrid, published by the Council of Statistics of the kingdom in 1864, and formed by Don Casiano de Prado, engineer of mines, member of the Commission of the Spanish Geological Map. 1854.

(6.) Mapa geologico de la provincia de Palencia, traced by Don Casiano de Prado, member of the Commission of the Spanish Geological Map, 1856.

(7.) "Cuadro grafico de altitudes de la parte septentrional de la provincia de Palencia," traced by the section under the direction of Don Casiano de Prado, member of the Commission appointed to form the Spanish Geological Map, 1856.

(8.) Plano geologico de la Cuenca carbonifera de San Juan de las Abadesas, province of Gerona, by Amalio Maestre, Madrid, August 15, 1855.

(9.) Comision del Mapa geologico. Secion geografica meterologica. Directed by the member and first class engineer, Dr. Jose Subercase.

(10.) Mapa geologico estratigrafico de las montanas de la provincia de Palencia, by Don Casiano de Prado, 1857.

(11.) Sections of the N. and N.E. of the province of Madrid, which include the Sierra of Truda, and cerros called de Concha within the limits of La Puebla de la Muger muerta.

3153c. Illustrations of the progress of **Geology, Mining,** and **Metallurgy** in **Spain,** selected from works published by the contributor. *Don B. Federico de Botella y de Hornos, Madrid.*

(1.) "Descripcion Geologica Minera de las Provincias de Murcia y Albacete (antigno reino de Murcia)," by B. Federico Botella y de Hornos, first class engineer of the National School of Mines, 1 vol., grand folio, 22 plates, and numerous drawings in the text.

(2.) Geological and agronomical plan of Murcia and the surrounding country, giving the system of irrigating canals employed at the Huerta of Murcia.

(3.) Sierra of Carthagena. Lead foundry. Spanish slag hearths. Atmospheric furnaces. Blast furnaces. Cementing furnaces. Compressed air furnaces used at the Escombrera Works.

(4.) Sierra of Carthagena. Desilverization. Condensing furnaces. Refining furnaces. Pattison's crystallizing boilers. Implements and tools employed in working these boilers.

(5.) Mazarron. General plan of alum works. Serrata of Lorca. Advantages of sulphur. Furnaces of horizontal cylinders. Furnaces of vertical cylinders.

(6.) Sierra of Carthagena. Metallurgy. Moulds used for mixing the bricks used at the furnace. Atmospherical furnaces. Moulds employed for pressing the lead out of the furnace. Silver in cupella. Blast furnaces, with ventilators and bellows. Moulds for casting leaden bars. Boilers and other implements.

(7.) Sierra of Carthagena. Mechanical preparations employed at the works. Works at Escombreras. Round buddles worked by steam. M. Victor Simon's classifier. Water clarifier.

(8.) Topographical and geological plan of the Sierra of Carthagena.

(9.) Sierra of Carthagena. Geological section from Cabera Gordo to Cerro de Santo Espiritu.

(10.) Sierra of Carthagena. Mechanical preparations used in metal works. American crushing machine. Classifying trommels. Dividing trommels. Refining trommel. Sieves. Classifying cones. Classifying cases. Concave rolling table. Lifter used for minerals.

(11.) Sierra of Carthagena. Cupellation. Cupellating furnace. General plan of desilverizing works.

(12.) Drawing representing a statuette of Hercules 0·152 met. H. found at the Esperanza mine in 1840.

Lamps, jars, and vessels of different kinds found at the mines of the Sierra of Carthagena.

Bronze lamp found at Lorca. Bas-reliefs. Fragment of a statue found in a mine of the Sierra of Carthagena. Lead bar of the Roman time, with inscription, found at the Sierra of Carthagena.

(13.) Sierra of Carthagena. Mechanical preparation used in lead works. Works at Escombreras. Crushing cylinders worked by steam. Vertical grinders. Classifying trommels. Sieves. Tables for shaking minerals.

(14.) Topographical and geological plan of the mines and works of San Juan de Riopar (province of Albacete).

(15.) Sierra of Carthagena. Geological sections.

(16.) A geological map of the provinces of Murcia and Albacete. (Spain).

(17.) Sierra of Lorca.

Fossil fish found in the sulphur mines.

(18.) Cerro of Mazarron. View of the vein of mineral of San Juan. Sierra of Orihuela. Peña del Gato. Sulphur mines at Hellin. View of the volcanic cerro of Monagrillo. Cerro of Mazarron. Section of an ancient excavation at Pedreras Viejas. View of the sulphur mines at Hellin.

(19.) Sierra of Carthagena. Mechanical preparation of minerals. Drawer sieves. Round buddles employed at the sierra. Cylinders used for crushing minerals worked by horse power. Sifters.

ADMIRALTY—HYDROGRAPHIC DEPARTMENT.

ORIGINAL (MS.) JOURNALS AND LOG BOOKS, &C. KEPT BY CELEBRATED ENGLISH NAVIGATORS BETWEEN THE YEARS 1768 AND 1825.

3154. Dampier's original MS. Chart of his voyage to New Guinea, 1699–70.

3155. Cook, Captain James. Journal of the proceedings of H.M. bark the "Endeavour," in a voyage round the world; performed in the years 1768–69–70–71. Folio.

3156. Cook, Captain James. Journal of the proceedings of H.M. sloop "Resolution," in exploring the South Atlantic, Indian, and Pacific Oceans, in the years 1772–73–74–75. Folio, with charts.

3157. Bligh, Captain William. Log of the proceedings of H.M. armed vessel "Bounty," in a voyage to the South Seas, to take the bread-fruit from the Society Islands to the West Indies, in the years 1787–88–89. Folio. Including an account of the mutiny.

3158. Bligh, Captain William. Log of the proceedings of H.M.S. "Providence," on a second voyage to the South Seas, in the years 1791–92–93. Folio. 2 vols.

3159. Franklin, Sir John. Log of the proceedings of H.M. hired brig "Trent," in a voyage towards the North Pole, in the year 1818. Folio.

3160. Parry, Sir Edward. Log of H.M.S. "Alexander," in a voyage for the discovery of a North-west passage, in the year 1818. Folio.

3161. Parry, Sir Edward. Official journal of H.M.S. "Hecla," in the years 1819–20. Folio. 3 vols.

3162. Parry, Sir Edward. Official journal of H.M.S. "Fury," in the years 1821–22–23. Folio. 2 vols.

3163. Parry, Sir Edward. Log of H.M.S. "Hecla," in the years 1824–25. Folio.

CHARTS AND PLANS.

3164. North Atlantic Ocean (Chart). Compiled in the Hydrographic Office of the Admiralty. Scale, 0·5 inches to a degree of longitude.

3165. British Islands (Chart). Compiled from the latest Admiralty Surveys. Scale, 1·4 inches to a degree of longitude.

3178. Zanzibar Harbour, east coast of Africa (Plan). Surveyed by Commander W. J. L. Wharton, R.N. Scale, 1·5 inches to a nautical mile.

3179. Plymouth Sound and Hamoaze (Plan). Surveyed by Commander H. L. Cox, R.N. Scale, 6·0 inches to a nautical mile.

3180. Curves of equal Magnetic Variation, 1871. Compiled by Staff Captain F. J. Evans and Navigating Lieutenant E. W. Creak, R.N.

3181. Current Chart of the Pacific, Atlantic, and Indian Oceans. Compiled by Staff Captain F. J. Evans and Staff Commander Thomas A. Hull, R.N.

3182. Ice Chart of the Southern Hemisphere. Compiled by Staff Captain F. J. Evans and Staff Commander G. F. McDougall, R.N.

3183. Antarctic Charts lent by the Hydrographic Office.

S 91. New South Britain (South Shetland Islands), Captain Smith, 1819 (original drawing).
S 92. South Shetland Islands. Mr. Bransfield, 1820.
543. Kerguelen Island. Captain Cook, 1776–9 (original drawing).
445. Do. Captain Rhodes, 1799 (original drawing).
A 4323. Do. Compiled in Hydrographic Office, 1874.
A 3711. Heard and McDonald Islands. Captain Nares, 1874.
A 508. Powell's group (South Orkneys). Captain Powell, 1821–2.
L 1752. Louis Philippe Land. Captain Dumont D'Urville, 1838.
L 2115. Adelie Land and Côté Clarie. Do. 1840.
L 3125. Antarctic Continent. Lieutenant Wilkes, United States Navy, 1840. Auckland and Campbell Islands.
L 4589. Victoria Land. Captain James Clark Ross, 1841.

Atlases.

3184. Atlantic Pilot Charts.

These charts show in a graphic form the prevailing winds and other phenomena for periods nearly corresponding to the seasons of the year. A general chart of the ocean currents is also given.

3185. Wind and Current Charts for the **Atlantic, Pacific,** and **Indian Oceans.**

To these are added smaller synoptical charts showing lines of equal air temperature, barometric pressure, and sea-surface temperature.

3186. Officers' Atlases, containing a selection from the Charts supplied for the navigation of Her Majesty's Ships.

3187. Index to the Charts and Plans published by the Hydrographic Office of the Admiralty.

3187a. Globe illustrative of the **Earth's Magnetism.**

3187b. Maps illustrative of the **Earth's Magnetism.**

ROYAL GEOGRAPHICAL SOCIETY OF LONDON.

3188. Collection of Arctic Charts.

3188a. Pictorial Diagrams of the Arctic Regions.
Royal Geographical Society, London.

3188b. Pictorial Diagrams of the Aurora Borealis.
Royal Geographical Society, London.

3189. Arctic Maps. For list see Handbook.

3189a. Four Views, Antarctic Regions.
Royal Geographical Society.

3190. Manuscript Maps of Celebrated Explorers.

Year.	Title.	Name of Explorer.
1850	River Zambesi	Dr. Livingstone
1853	River Leeba	Dr. Livingstone
1854	Victoria Falls to Loanda	Dr. Livingstone.
1854	River Coanza	Dr. Livingstone.
1854	River Quango	Dr. Livingstone.
1855	Zanzibar to Uniamesi Sea	Erhardt and Redmann.
1855	Loanda to Victoria Falls	Dr. Livingstone.
1855	Country South of Zambesi	Dr. Livingstone.
1856	Victoria Falls to Tété	Dr. Livingstone.
1857	River Pangani	Burton and Speke.
1858	Khartum to Gondokoro	J. Petherick.
1858	Zanzibar to Ujiji	Burton and Speke.
1858	Kasé to Lake Victoria	Speke.
1859	Lake Shirwa	Dr. Livingstone.
1860	Sources of the Nile	G. G. Miani.
1860	Zanzibar to Gondokoro	Speke and Grant.
1861	Zanzibar to Gondokoro	Speke and Grant.
1861	Lake Nyassa	Dr. Livingstone.
1862	Khartum to Albert Nyanza	Sir S. Baker.
1862	Lake Albert Nyanza	Sir S. Baker.
1862	Zanzibar to Gondokoro	Speke.
1863	Sources of Nile	J. Petherick.
1868	Eastern Turkistan	G. H. Haywood.
1875	Lake Victoria	H. M. Stanley.

3190a. Diagram of Africa, showing Lieut. V. L. Cameron's route across that Continent, also the general river basins and drainage.

3190b. A Sectional Route, by Lieut. V. L. Cameron, R.N., C.B.

3191. Specimens of Printed Maps in the Journal of the Society.

Glaciers of the Mustakh Range, India, by Capt. H. G. Austen.
Canterbury and Otago, New Zealand, Messrs. McKerron, Haast, and Hector.
Vancouver Island, Dr. C. Forbes, R.N.
Small portrait (1 foot square) of Dr. Livingstone, considered the best likeness.

3192. Model of the Victoria Falls, River Zambesi. By T. Baines, Esq., F.R.G.S.

3193. Views. Descriptive Geography.

12 Water-coloured views of glaciers, Middle Island, New Zealand.
10 views of the Victoria Falls, Zambesi River, by T. Baines, Esq.
3 views in Eastern Turkistan, near Kashgar, &c., by G. H. Haywood.
Sketches of the natives, Island of Formosa, with map. Exhibited by Admiral Sir R. Collinson, K.C.B.

3194. Photographs taken in China. Four volumes. By H. Thompson (Paris Medallist).

3195. Two Views on the River Zambesi (oil paintings), by the late T. Baines, F.R.G.S.

3196. Collection of Publications of the Society.

A complete set of the Journals, 45 vols.
Arctic papers for the Expedition of 1875.
The lands of Cazembe, Lacerda's journey, &c.
Hints for Travellers.
A complete set of the "Proceedings," 19 vols.

3197. Geographical Diagrams (Wall Maps).

1. Smith's Sound.
2. Central America.
3. Vancouver's Island and British Columbia.
4. Abyssinia.
5. Mount Sinai.
6. Korea and Eastern China.
7. Pigafetta's Congo (Ancient Africa).
8. Caucasus.
9. Zeno's Map.
10. Spitzbergen.
11. South-west Pacific, Fiji Islands, &c.
12. Burma.

3198. Pictorial Diagrams (Geographical).

1. View of the volcano of Santorin, large.
2. " " small.
3. Crater of Kilauea, Sandwich Islands.
4. Murchison Falls (River Nile).
5. View in Fiji Islands.
6. " "
7. Ruined Esquimaux hut.
8. Aurora Borealis (five diagrams).
9. Section of an ice-blink or glacier.

3199. Ancient Maps of the **Sources** of the **Nile.**

1.	1508 - - -	By Ptolemy.
2.	1650 - - -	Sebn. Munster.
3.	16th century - -	?
4.	1618 - - -	?

3200. Miscellaneous Contributions by the **Geographical Society.**

Three cases of select specimens of Cartography (105 in No.).
Educational models, various.
Engraved Portraits of celebrated explorers.
Barent's relics, 1597; water-coloured drawing.
Pizigani's Map of the World, 1367.

MAPS, GLOBES, AND MISCELLANEOUS OBJECTS BY VARIOUS CONTRIBUTORS.

3201. Models to illustrate the arts of Camp Life.
Francis Galton, F.R.S.

This case of models and specimens was made at the same time as 10 others that were constructed in 1858, by order of the War Office, after the design of a set which Mr. Galton caused to be made, and had presented to the Royal Institution at Woolwich in the previous year. Their object was not only to interest and instruct individual soldiers, but rather to suggest to instructors the precise subjects on which practical classes in the arts of camp life may most usefully be engaged. A catalogue accompanies the case in which the models are contained, and in this an asterisk is placed opposite to those objects which Mr Galton's experience leads him to prefer for the purpose. "An old cam-" paigner's acquirements consist partly in knowledge and partly in handiness. " Field lectures, illustrated by experiments, may convey the first to an " intelligent novice, and it was hoped that these models might serve to " explain what kind of things must be made by his hands, before he can " acquire the latter."

The examples illustrate the various modes of the production of fire, the procuring, purifying, and carriage of water, cooking, the uses of portable food, substitutes for boats, cattle enclosures, expedients for tools and appliances in various handicrafts, tenting, hutting, and various other needs of camp life.

3202. Stereoscopic Maps, taken photographically, from models in relief. *Francis Galton, F.R.S.*

A much clearer notion of the physical features of a country may be obtained from a model in relief than from an ordinary map, however carefully executed, but the great weight and cumbrousness of models makes them unsuitable for the library or for travel. The chief advantages of both methods of illustration may in great measure be secured by stereoscopic maps taken photographically from models. The accompanying specimens were exhibited in illustration of a memoir read before the Royal Geographical Society in 1865, a copy of which is placed beside the photographs. It is there shown that the proposed plan has two other unexpected advantages. First, owing to causes there explained, we are able to deal with models of considerable dimensions both laterally and longitudinally, for when such a model has been photographed stereoscopically in separate squares, and the prints have been properly united,

it becomes possible to view any part of the map with pseudo-stereoscopic if not with stereoscopic effect. Secondly, it is shown, that the insertion of names improves the appearance of relief in models, and consequently in stereoscopic representations of them, while it spoils the effect of shading in ordinary maps.

3202c. Perspective Map of Africa, according to French, English, and German travellers.

M. Launay, Professor at the Lyceum of Caen.

This map was executed previously to the publication of the accounts of Mr. Stanley, respecting Lake Ukérinė, of Lieut. Cameron respecting Lake Tanganiyka, and of M. Grandidier respecting Madagascar.

3203. Map of **Gaul,** showing by different coloured tracings the relative antiquity and importance of the Roman roads.

M. Hayaux du Tilly, Paris.

3203a. Old Spanish Map of the Province of Aragon, &c., with the roads, bridges, hill-shading, &c., inserted in MS. by Captain H. Bristow, by means of the pocket-sextant, No. 3107a.

H. W. Bristow, F.R.S.

During the Peninsular War, great difficulty was experienced in getting accurate maps of Spain for the British army.

The most accurate Spanish maps then procurable were old, very defective, and nearly useless as route maps, owing to the roads, hill-shading, &c. not being shown upon them. These details had to be supplied for the use of the army, by the officers attached to the Quartermaster-General's department, the engraved maps serving as the groundwork for the new survey.

The old Spanish map of the province of Aragon and surrounding districts is one of those maps upon which the roads, bridges, the defences of Saragossa, and other details, were so supplied in MS. by Captain Bristow, by means of the pocket-sextant, No. 3107a.

3204. Photographs from the original surveys, representing the present mode of reproducing the ground by equi-distant curves:—

1. Half a Norwegian square mile, on the scale of 1·25000, used in lower tracts, well cultivated and more densely inhabited. The curves representing a rise of 25 feet.
2. A Norwegian square mile, on the scale of 1·50000, used in the higher and less inhabited parts of the land. The equidistant curves represent here a rise of 100 feet.

Survey Office, Christiania, Norway.

3204a. Specimen Sheets of the two most important Productions of the Topographical Department at St. Petersburg. Copper plate.

The Topographical Department of the Imperial Russian General Staff at St. Petersburg.

1. Topographical map of the western part of European Russia in 507 sheets. Scale, 1:126,000.

2. Special map of European Russia in 145 sheets. Scale, 1:420,000.
   a. Copies off copper plate in two colours.
   b. Transfer print off lithographic stone, and chromo-lithography in four colours, black for the skeleton and the writing; brown for the ground of the country; blue for the watercourses, and green for forests and woods.

3204b. Map of Trans-Caspia, in five sheets. Scale 1:840,000. Lithographed in Tiflis.

The Topographical Department of the Imperial Russian General Staff in Tiflis.

The dry bed of the Amu-Darja has been indicated on the map according to the latest survey.

3205. Map of the Hop-growing Districts of Central Europe, by Joh. Carl, editor of the General Hop Gazette, and C. Homann, containing:—

1. Agrarian statistical general map of the European hop-growing districts on the Continent and in England.
2. Special map of Bavaria.
3. " Bohemia.
4. " Wurtemberg and Baden.
5. " Belgium.
6. Tabular and graphical representations of the cultivation of hops, and of the hop consumption of the whole world.
7. Classification of the various sorts of hops.
8. Comparative tables of the agrarian measures and commercial weights.

J. Carl and C. Homann, Nüremberg.

The maps represent the cultivation of hops in a manner not to be found elsewhere. The agrarian statistical general map shows the hop cultivation of the Continent and England, and contains special maps of the principal hop-districts of England, Bavaria, Bohemia, Württemburg, Baden, Belgium, &c. The tabular and graphical representations contain very important statistics as to the cultivation, production, and consumption of the whole world, which may be summed up as follows:—

—	Surface under Cultivation.	Production.	Consumption.	Production + or − Consumption.
	hectares.	cwts.	cwts.	cwts.
Germany - - -	37,910	477,111	321,500	+ 155,611
England - - -	25,096	384,090	600,000	− 215,910
Austria - - -	7,711	92,532	100,000	− 7,468
Belgium - - -	6,500	97,500	15,000	+ 82,500
France - - -	4,000	48,000	48,000	—
The rest of Europe - -	619	8,454	25,000	− 16,546
Total Europe - -	82,346	1,107,687	1,109,500	− 1,813

The produce and surface under cultivation of the hop districts of the

different countries are also shown in the same way. The average production of one hectare in an average crop is as follows:—

In Prussia	per hectare 12 cwts.,	in all	59,400	cwts.
„ Bavaria	„ 12 „	„	212,556	„
„ Württemburg	„ 15 „	„	73,595	„
„ Baden	„ 15 „	„	26,310	„
„ Alsace and Lorraine	12 „	„	9,000	„
„ the rest of Germany	12–15	„	15,150	„
Total produce of an average crop in Germany			396,011	„

The most noted hop districts are all indicated by the colouration; the principal localities of production are also indicated. All the notices of this map that have appeared in the various journals have been highly favourable.

3206. Wetzel's Wall Map of Mathematical Geography. *Dietrich Reimer, Berlin (Reimer and Hoefer).*

3207. Kiepert's Physical Wall Maps, viz.:—
Wall map of the Eastern Planiglobe.
Wall map of the Western Planiglobe.
Map of Europe.
Map of Asia.
Map of Africa.
Map of North America.
Map of South America.
Map of Australia.
Dietrich Reimer, Berlin (Reimer and Hoefer).

3207a. Physical Map of the Colony of Natal, showing the central highlands, the northern one-river basin, and the southern many-river system of watersheds. *Dr. Mann.*

The central highlands are shown to be a spur from the inland mountain frontier, or Drakenberg range, with finger-like subdivisions descending to the coast to constitute the many-river system which is developed there.

3208. Möhl's Orohydrographical Wall Map of Germany. *Th. Fischer, Cassel.*

The maps are lithographed in the exhibitor's offices after a method of representing the earth's surface, first published by Professor Möhl. The printing is effected by scraped and chalk stones, besides the ordinary colour stones.

3209. A similar **Map** of **Hesse-Nassau.** *Th. Fischer, Cassel.*

3210. Another one of **South-western Germany.** *Th. Fischer, Cassel.*

3211. Carta geografica de la Républica de Costa Rica (Centro-America). Proporcion 1 : 500,000. Efectuada par L. Friederichsen, 1876. *L. Friederichsen, Hamburg.*

This map has been drawn and produced, on the foundation of important original materials, by Mr. L. Friedrichsen, under the autbority of the Go-

vernment of Costa Rica. It shows for the first time the geography of the Republic of Costa Rica on a large scale.

3213a. Map of the Central Part of the Chain of the Caucasus; scale, $\frac{1}{500000}$. *M. Ernest Favre, Geneva.*

Geological map of the central part of the Caucasus, executed by M. Ernest Favre from his own observations and extracted from "Recherches géologiques "dans la partie centrale de la chaine du Caucase" (H. Georg. Geneva and Bâle, 1875) by the same author.

3212. Portfolio, containing **Maps** in **Copper-plate Print.**

3213. Portfolio, containing **Maps** in **Lithographic Print.**
Bau Deputation, Hamburg.

3213b. Portfolio, containing reductions of the survey sheets to scale of 1 : 4000, and trigonometrical chart, scale, 1 : 50,000 lithographed. *Bau Deputation, Hamburg.*

3213c. Portfolio, containing reductions of the survey sheets n scales of 1 : 1000 ; 1 : 4000, and 1 : 20,000 on copper plates.
Bau Deputation, Hamburg.

3215. Portfolio, containing **Maps** and **Drawings.**
Bau Deputation, Hamburg.

3216. Plan, 1 : 4,000. Sect. IV. galvanoplastic relief plate.
Bau Deputation, Hamburg.

3216a. Galvanoplastic Relief Plate of Section IV. of the before-mentioned copper plate print. *Bau Deputation, Hamburg.*

3217. Relief Maps of Bergedorf.
Bau Deputation, Hamburg.

3217a. Two Relief Maps, one of the town of Bergedorf and its environs, produced from the lithographed sheets. Longitudinal scale=scale of height=1 : 4000, the other parts of the area of Bergedorf, produced from the transfer-print sheets drawn for that purpose on cartoon paper. Longitudinal scale=scale of height= 1 : 1000. *Bau Deputation, Hamburg.*

Explanations.

As a basis for the survey of Hamburg, the geodetic labours of Councillor Schumacher, Astronomer, are made use of, and in particular the base measured by him in the neighbourhood of Hamburg, in Holstein, in the years 1820 and 1821. At the suggestion of the technical adviser of the public buildings deputation, Engineer Lindley, a new survey and drawing of a new map on the scale of 1 250 was resolved upon in the year 1845, chiefly for technical purposes, and the necessary triangulation for that object executed by Dr. A. C. Petersen, under the direction of Schumacher.

In the year 1863, the survey of the entire territory was commenced in connexion with the survey of the city for the Doomsday Book (land registry), and concluded in the year 1868. The additional triangulation work required for that purpose, which was commenced simultaneously with the divisional survey, was connected with the already determined trigonometrical points of the town, and then with the base of Holstein. The number of trigonometrical points amounts to 1663, and the station points among the same, 993 in number, have been marked, with a very few exceptions, by granite pillars sunk into the ground. The angles were repeatedly measured by means of an 8-inch theodolite; the trigonometrical net corrected and adjusted according to the method of least squares, which was followed by the calculation of the horizontal rectangular co-ordinates, from which the geographical position was deduced by a very simple method. As origin of the system of co-ordinates, the spire of the large St. Michael's Church had already been fixed upon, and its geographical position determined as follows:—

Latitude = 53° 32′, 55.7″

Longitude E from Greenwich = 9° 58′, 41.75″.

The bailiwick of Bergedorf, formerly belonging to the joint jurisdiction of Hamburg and Lübeck, having been incorporated with the territory of Hamburg, the survey was extended to this area; and for this district a new division of survey sheets was adopted since the introduction of the metre standard.

The scales employed in drawing the maps are:—1:250, and 1:1000; for the new division of the sheets 1:200, 1:500, and 1:1000. Exact levels are given all over the entire territory, and bench marks are durably established in sufficient number. Connected with these, special levelling will be carried out by means of distance and altitude measurement.

In the adjoining parts of the territory not belonging to Hamburg, so far as such is still made use of for the maps to be published, levels will be taken by means of aneroid barometers.

The reduction of the survey sheets is effected by means of a specially constructed pantograph.

The multiplied copies will be published in scales of 1:1000, 1:4000, 1:20,000, and 1:50,000 (**3213b** and c), by O. Meissner and Behre, in Hamburg.

According to the directions given in the plates for the distance and the altitude measurements, the latter will be executed by the tachymeter, **3079a.** An ordinary levelling staff, divided into centimetres, will be employed for the purpose. A survey field book illustrates the work actually executed for a portion of the bailiwick of Bergedorf.

The co-ordinates of the station points required for levels will be calculated from those of known trigonometrical points, or from the polygon points of the detail survey, and entered in the survey sheets. In the principal polygons the distances between the station points will be measured with chains, or sheet-ribbons, and the altitudes determined by levelling. A synoptical table of results obtained by distance and altitude measurements, with the directly executed longitudinal measurements and with the geometrical levellings, is given. It should be mentioned that this work was executed in November 1874, in unfavourable weather, and that more satisfactory results are obtainable by this method.

When the station points have been plotted on the survey-sheets, and the levels of the altitude points have been calculated from the field book, these latter are plotted on tracing paper, containing the sheet divisions, the station points, and more or less the situation of the respective survey-sheets. For plotting the altitude points a transferrer is used, made either of metal or of

paper, when the latter it is adjusted with its centre point under the corresponding station point, according to the horizontal angular measurements, and then all the altitude points based on this station are sketched on the tracing paper, their levels being noted; when all the altitude points have been marked down, then the construction of the contours, commenced on the assumption that the slope of the ground is uniform between two altitude points, the position of the intervening contour lines, can be determined by the construction of similar triangles; this operation can, however, be avoided by the use of the instrument (**3127a**) devised for this purpose. If, for example, the altitude heights marked 30.5^m^ and 32.2^m^ have been ascertained, the difference of which amounts to 17 decimeter, the two contours for 31 and 32 metres will fall between these two points. The edge of the mirror of the variable scale is applied to the two points; the cylinder is turned until 17 parts of the division projected on the paper by the mirror fall between the points; the cylinder is then moved in the direction of its axis until the corresponding divisional marks 30.5^m^ and 32.2^m^ have been reached, and the points of section of this line with the contours for 31 and 32 metres are marked off. A better general view of the surface of the country divisions is afforded by the models produced from these plans.

3229a. Portfolio, containing various publications; viz.—

(*a.*) "Vermessung der Stadt Hamburg, Verzeichniss der trigo-"nometrisch bestimmten Punkte mit Netzkarte, Ham-"burg, 1848." (Survey of the city of Hamburg, table of the trigonometrically determined points with reticulated map of Hamburg, 1848), containing the rectangular co-ordinates of the points in the town and the nearest vicinity, with lithographed sketches, and division of sheets.

(*b.*) "Vermessung der Stadt Hamburg, Verzeichniss der trigo-"nometrischen Punkte nebst Dreüeckskarte, Hamburg, 1872." (Survey of the city of Hamburg, table of the trigonometrical points with trigonometrical chart. The latter in a scale of 1 : 50,000.)

(*c.*) "Nivellements und Hohenbestimmungen von Hamburg "und Ungebung, ausgeführt abseiten des Vermessungs-"bureaus in den Jahren, 1869–1872. Mit einer Karte, "Hamburg, 1872." (Levellings and determination of the heights of Hamburg and its environs, executed by the Survey Department in the years 1869–1872. With a map, 1872.)

(*d.*) "Verzeichniss von Höhenpunkten in Hamburg und Unge-"bung, bestimmt durch geometrische Nivellements "abseiten des Vermessungs-Bureaus in den Jahren 1869 "bis 1872, Hamburg, 1872." (Table of the heights of Hamburg and its environs, as determined by geometrical levellings, executed by the Survey Department in the years 1869 to 1872, Hamburg, 1872.)

(*e.*) "Distanz- und Hohenmessung, Formeln und Tabellen "behufs Aufnahme und Hohenbestimmung, u.s.w. Ham-

" burg, 1873." (Distance and altitude survey. Formulæ and tables for survey and determination of the heights, &c., Hamburg, 1873.)

(*f.*) "Ueber die Ausführung von Höhen-Messungen mit dem " Aneroid-Barometer. System Reitz, aus der Fabrik von " R. Deutschbein in Hamburg, u.s.w. Hamburg, 1874." (Levelling with the aneroid barometer. System of Reitz, from the manufactory of R. Deutschbein in Hamburg, &c., Hamburg, 1874.)

(*g.*) "Vermessung von Hamburg, u.s.w. 1873;" Kurze Darstellung der im Hamburgischen Gebiete ausgeführten geodätischen Arbeiten. (Survey of Hamburg, &c., 1873; short description of the geodetic works executed within the territory of Hamburg).

Bau Deputation, Hamburg.

3230. Field-Book (manual on executed height and distance measurements). *Bau Deputation, Hamburg.*

3230a. Portfolio containing representations of the hypsometrical works, namely:—

(*a.*) The tables mentioned under for distance and levels.
(*b.*) Tables for the staffs used for distances and levelling.
(*c.*) Field-book, with distances and levels taken in a part of the area of Bergedorf.
(*d.*) Transferrer for plotting heights.
(*e.*) Table containing the stations and the polygon lines for the distances and levels executed in a part of the area of Bergedorf, with a synoptical summary of the results obtained by this method with reference to direct measurement of length, and with regard to geometrical levelling.
(*f.*) A sheet with annotations of the altitude points determined by distance and height measurement, and the one metre contours constructed from them; scale 1 : 4000 of part of the adjoining Holstein territory.
(*g.*) Sheet of one metre contours, with the stations and polygon lines; scale 1 : 1000 of part of the area of Bergedorf.
(*h.*) Plan of the town of Bergedorf, with one metre contours; scale 1 : 4000, lithographed.
(*i.*) Plan of part of the area of Bergedorf, with one metre contours; scale 1 : 1000, lithographed print on cartoon paper. *Bau Deputation, Hamburg.*

3218. Map of the Earth, projected on a regular **Dodecahedron.** *George H. Darwin.*

3219. Map of the Earth, projected on a regular **Icosahedron.** *George H. Darwin.*

In these maps, the representation of the earth is effected by supposing that the globe is inscribed to a regular dodecahedon or icosahedron, and then projected on the faces of the solid by lines radiating from its centre. The faces of the solid are then opened out and laid flat, in such a manner as to represent the equator as nearly as possible by a straight line. In the case of the icosahedron the pole's axis is supposed to pass through two corners of the solid. In the case of the dodecahedron, the polar axis is supposed to pass through the middle points of two opposite faces, and these two faces are cut up into triangles.

3219a. Great Spheroidal and Universal Atlas.
M. Haniche de St. Senoch, Paris.

This work is divided into seven parts the first two of which are devoted to general geography.

1st part. Maps developed in the shape of a Planisphere, and showing from different points of view the comparative status of geographical knowledge. (9 maps.)

2nd part. Aspects of the terrestrial globe, seen in projection upon plans perpendicular to divers great circles corresponding to the position of the chief countries. (8 maps.)

The five other parts are devoted to detailed maps of the five parts of the world.

3219b. Map of France only.
M. Haniche de St. Senoch, Paris.

3220. Maps in Relief, embossed in paper, showing rivers, towns, railways, &c.; also, in relief, mountains, valleys, and other physical features of the earth's surface.

Larger series, 23 in. by 21 in.

England and Wales.	Europe.
Scotland.	Africa.
India.	Palestine.

Smaller series, 10 in. by 8 in.

England and Wales.	Europe.
Scotland.	Palestine.

Henry F. Brion.

3221. Four Tableaux of Original Models for composing a new relief atlas by means of stamp-printing.
Ed. Uhlenhuth, Anclam.

3222. Specimen Impressions of Relief Maps in different stages of development. *Ed. Uhlenhuth, Anclam.*

3223. Section of the Brocken Mountain-group of the large relief map of the Hartz Mountain, composed in 1 : 2,500, according to the altitude curves of the plane-table sheets of the Royal Prussian General Staff, showing the layer formation in papier-mâché and wax. *Ed. Uhlenhuth, Anclam.*

3224. Brocken Group, executed in gypsum, and marked with the situation. *Ed. Uhlenhuth, Anclam.*

3225. Terrestrial Globe of 80 cm. diameter, with complete frame-stand. *Dietrich Reimer, Berlin.*

3226. Terrestrial Globe of 34 cm. diameter, on a wooden stand. *Dietrich Reimer, Berlin.*

3227. Another one, on an iron stand with semi-meridian. *Dietrich Reimer, Berlin.*

3228. Another, with complete frame-stand. *Dietrich Reimer, Berlin.*

3229. Tables for Measuring Distances and Heights. *Bau Deputation, Hamburg.*

3231. Terrestrial Globe, 48 cm. diameter. *Ernst Schotte, Berlin.*

3232. Four Maps of France. *M. Delesse, Paris.*

1. *Agricultural Map of France.*—On this map is shown the various cultures or crops by conventional colours, the shades of which are proportionately darker according as the returns or yields are more important.

If we consider the arable lands, which occupy the largest portion of France, they will of course vary yearly in their produce, but it is possible to form a money estimate of their average annual return per hectare.

By studying the figures for the cantons, taking into account their shape, as well as their elevation, and the mineral composition of the soil, curves have been traced showing the annual revenues of 20, 40, 60, 80, 100, and 120 francs.

For the woods, meadows, and vineyards, where the culture is permanent, there have also been traced curves of equal revenues, showing the average returns per hectare.

Giving to the cultivated lands, the woods, fields, and vineyards, their conventional colours, the depth of shade of these has been graduated according to the various curves to which they correspond.

Although the map is on a reduced scale of 4,000,000, it nevertheless enables an estimate to be formed of how the agricultural riches of France is spbdivided.

2. *Hydrological Map of the Seine and Marne.*—The hydrological map of the departments of the Seine and Marne is on a scale of 100,000, and shows the underground stores of water of the region of La Brie. These water supplies are represented by certain conventional colours, and their form has been determined by the geological investigation of the subsoil, from surveys and borings made over a network of wells. In fact, the surface represents the sides which have been ascertained for each well below the level of the sea, and these are shown by horizontal curves of 20 metres distance, so that it is very easy to trace the course of the flow of the water supplies.

In the region of La Brie, the principal subterranean water beds correspond with the most important argillaceous strata, that is to say, the green clays, the plastic clays, and in certain points, the building limestones of La Beauce.

Moreover the subterranean sheets of water known as those of infiltration correspond to the various watercourses which traverse La Brie, and especially the rivers, such as the Seine and Marne.

The waterbed supported by the green clays is by far the most important in the plateau of La Brie, whilst in the valleys the wells are supplied by the beds of infiltration.

The hydrological map of the Seine and Marne enables a judgment to be formed of the depth it would be necessary to attain in order to reach the water deposits, and an opinion can also be formed of the geological nature of the soil which would be met with in boring. A judgment can also thus be formed of how the water sources and beds act in an absorbent soil like chalk; a question which is of considerable interest at the present time, when a tunnel is proposed to be dug between France and England

3. *Lithologic or Submarine Chart of the Seas of Europe.*—This chart, compiled from hydrographical observation, serves to convey an idea of the nature of the rocks which are covered by the seas of Europe.

The bed of the seas is characterised by horizontal curves traced from the depths ascertained by a great number of soundings. The beds distinguished are the stony rocks of various kinds, the clays, the mud, the muddy sand, the gravelly mud, the sand, the grit, and the pebbles.

These are represented by conventional colours, as in geological maps, but one colour indicates the same lithological character The localities most rich in shells are also determined and marked by shadings.

Among the rocks which form the bed of the seas, some are anterior to the present epoch, and are constantly worn or beaten, and are covered by deposits. They may be stony, like the granites or paving stones and the limestones, but they are occasionally tender and brittle like the clay, and sometimes movable like the sand and the pebbles.

The rocks anterior to the present period are seen principally in the parts which jut out along the coasts, in the straits, and in the localities where the tides run strong The rocks belonging to the deposits of the present epoch are essentially of the movable character, they fill especially the places having hollows or depressions; they cover the plateaux, and they accumulate chiefly in depths where the tides or currents are not rapid.

The geological study of the coasts occasionally enables us to trace beneath the sea the prolongation of the rocks which have emerged, and to study portions of the geological submarine chart.

4. *Ancient and present Seas of France.*—An endeavour has been made to represent the ancient seas of France in the silurian period, the trias, the lias, the eocene, and the pliocene Starting with the facts furnished by geology, there have been comprised in one blue tint all the points in which the existence of soils deposited by these various seas have been established. But these soils are not now what they were when originally formed, they have been partially destroyed by the atmosphere and by flowing waters; they have been sundered by faults; they have been subjected to numerous and complicated overthrows, and it is chiefly their actual condition that it is proposed to describe. With this view, in order to study the lands in the parts where they are now visible, as well as in those where they are covered up, they have been represented in relief by means of horizontal curves. The curve having the side O is particularly interesting, as it shows the intersection of the actual level of the sea with the surface of the land under consideration, and, if we admit that the sea level remains constant, all the portions of land which are formed above this curve have necessarily been elevated.

The total of horizontal curves shows the orography of the superior surface of land, which has resulted from the wasting and changes since its deposition.

By the aid of these maps we can well see that while a basin has received the superposed soil, and the original elevations and depressions are to a

rtain extent maintained, they have been attenuated successively in the ore recent soils. Moreover, where a soil has been raised on the flanks of ountains, it presents generally a strong declivity, which is well shown by e approach of the horizontal curves, but disappears at a short distance from e mountains. The sixth map of the plate represents the actual seas of rance, of which it shows the orography. It indicates also the proportion f carbonate of lime in the marine deposits which form on the shores, the pheaving and subsidence of the coasts, the distribution of the rainfall, &c.

3232a. Specimens of Charts published by the Navy Department.

General Direction of the Depôt of Marine Charts and Plans, Paris.

Cherbourg Roads, 1836.
Directions of currents in the Channel, 1855.
Coasts of the mouths of the Rhône, 1848.
Coasts of Italy, 1863.
Approaches to Brest, 1868.
Island of Ouessant, 1868.
Guadaloupe, 1874.
Japan, 1874.

3236a. Collection of Maps, Plans, Plaster Casts, and Photographs. *M. Delagrave, Paris.*

3236b. Map of Travel, setting off by differently coloured racings the relative antiquity and importance of the Roman oads. *M. Hayaux du Tilly, Paris.*

3237. Proposed Itinerary for the Voyage of a Circumnavigating Vessel, for 1877.

2. Also, view and section of a vessel fitted for voyages of observation round the world.

La Société des Voyages d'Études autour du Monde, Paris.

These drawings have been executed in the office of the Société des Forges t Chantiers de la Méditerranée, in accordance with the designs of M. Dupuy e Lôme, member of the Institut, and President of the Administrative Council f the Société des Forges et Chantiers.

NOTE.—The Société des Voyages d'Études autour du Monde (society for aaking voyages round the world for scientific observation) is being formed y a number of persons with the intention of creating a new element in the igher branches of practical instruction.

Its immediate object is to organise regular voyages round the world, in a essel specially fitted for that purpose, and in which will be found united all he facilities and appliances suitable for developing and acquiring useful nowledge relative to the various branches of science, economic, geographic, nd industrial, and particularly for obtaining information on the commercial es urces, actual wants, and special tendencies of distant lands.

This progressive attempt has received the official approbation of the geographical societies of England and France, the French Meteorological Society, e Society for the Encouragement of National (French) Industry, and the cclimatisation Society. It includes the last-named society among its ounders.

The managing committee nominated by the founders of the society, having carefully considered their plans, and decided on their course of action, both as to the conditions of service and the construction of the first vessel, and being on the point of accomplishing their mission, considered that it would be interesting to very many persons connected with instruction or voyages to be made acquainted with the programme of this novel enterprise.

3238. Collection of Models and Maps.
Frère Alexis, Gochet.

3239. Diagrams showing the amount of the **Misrepresentation of the Sphere** by plane maps in the most usual projections.
C. W. Merrifield, F.R.S.

3240. Lecture Diagrams (4) of Alpine Glaciers, of Switzerland, by the late G. V. du Noyer. Used in illustration of lectures at the College of Science. *Edward Hull, F.R.S.*

3241. Working Model of a Geyser.
Prof. W. F. Barrett.

This is a lecture table arrangement constructed upon the method first suggested by Prof. Wiedemann, and illustrated on a large scale by Prof. Tyndall Water is put into the tube and heated by a gas flame below. Under the pressure of the column of water, the boiling point is raised, and the pressure being lessened by the overflow of water into the basin, steam is suddenly generated, which ejects the water periodically to a considerable height. When the tube is cooled, the eruption from this small model can eject the water at least 20 feet high A large form, on the same pattern, similarly ejects the water 30 or 40 feet high. The size of the larger model is as follows Tube of galvanised iron, 7 feet long, 4 inches in diameter below, and 2 inches diameter above Basin, say 4 feet in diameter. A spiral row of gas jets heats this larger tube one-third of the way up, as well as a large gas flame below.

3242. "Cadre-Mobile." Frame for wall maps and pictures used in schools. *Ernest Recordon (Geneva).*

3243. Guthe's School Wall Map of Hanover. Newly drawn by W. Keil. *Th. Fischer, Cassel.*

3244. G. Rohlfs' Three Months in the Lybian Desert, with photograph and map. *Th. Fischer, Cassel.*

Rohlf's volume forms the first part of the report on the Expedition for the Investigation of the Libyan Desert, carried out under the auspices of His Highness Ismail Pasha, Khedive of Egypt

3245. Album of Printing Specimens. Colour-printing specimens for works by Lischke, von der Decken, Heuglin, Rohlfs, &c. *Th. Fischer, Cassel.*

The album contains proofs in colour printing of plates from the geographical and natural history works of Heuglin, Von der Decken, &c.

3246. Journal of the Museum Godeffroy. 3 vols., 4to.
F. C. Godeffroy, Hamburg.

ournal is the scientific organ of the "Museum Godeffroy." It is
xclusively devoted to the publication of the results of the investiga-
the travellers of the Museum in the Pacific, and contains geograph-
nographical, and natural history memoirs. The management lays
r stress upon the production of technically perfect figures of the
described, so that the plates accompanying the journal must be
as in many respects patterns of the most various modes of pictorial
tion. Particular care is also devoted to the production of original

8a. Reproduction of the **Chart** made in 1500 by Tuan
osa, Columbus's pilot, after his second journey with Colum-
1493. *Archæological Museum, Madrid.*

s taken from the original at the Ministry of Marine, at Madrid. It
considered a Mapa-mundi. The part applying to America is most
it, as it was drawn out by this pilot in the second journey which he
h Columbus in 1493. This chart was made for Queen Isabella, and
the following inscription :—*Tuan de la Cosa la fizo en el Puerto de
Maria en Anno de* 1500.

eproduction is accompanied by a memoir on the same subject, written
Fernander Duro, and published in the "Museo Español de Antigue-

SECTION 16.—GEOLOGY AND MINING.

West Gallery, Room L and M.

I.—GEOLOGY.

1. Special Collections. Geological Society of London.

a. Geological Instruments and Apparatus.

3247. Apparatus, &c. employed in **Sir James Hall's** celebrated experiments. *The Geological Society of London.*

A series of specimens, with the instruments employed in their preparation, illustrating the remarkable experiments carried on by Sir James Hall, Bart., between the years 1787 and 1805, to confirm some of the positions taken up by Dr. James Hutton in his celebrated "Theory of the Earth." The series consists of the following—

(1.) A selection of whinstone and lava rocks which have been fused and allowed to cool under various conditions. These are the products of the earliest experiments, which were carried on in ordinary clay crucibles.

(2.) Porcelain tubes employed in the first attempts to submit carbonate of lime and other substances to a high temperature under pressure.

(4.) "Gun-barrels," employed in the final and successful experiments for the same purpose, with the cylinders of rock operated upon.

(The collection of apparatus and specimens from which the above are selected was presented to the Geological Society of London by Captain Basil Hall, R.N., at his father's death.)

3248. Geological Model of the **South-east of England** and **part of France,** including the **Weald** and the **Bas Boulonnais.** Founded upon the maps of the Ordnance, Admiralty, and Geological Surveys. Scale, 1 inch to 4 miles. *W. Topley, F.G.S., and J. B. Jordan.*

This model illustrates the close connexion which exists between the geological structure of a district and the "form of the ground." The chief hill ranges and the broad longitudinal valleys correspond with the outcrops of hard or soft rocks; the transverse valleys, in which the main rivers run, cut across all the rocks alike.

3249. Agricultural Map of **Kent.** Scale, 1 inch to 4 miles. *William Topley, F.G.S.*

This map is founded upon the published maps of the Geological Survey, additions and modifications of colouring for agricultural purposes being made by the author. Stiff and retentive soils are coloured dark tints, grey, purple, and brown; light and absorbent soils, yellow or light green; calcareous and absorbent soils, blue.

he index notes briefly the quality of the soils; the character of the land, her chiefly arable, pasture, or woodland; and mentions a few of the more worthy crops of Kent.

250. Diagram illustrating the comparative **Agriculture** of land and Wales. *William Topley, F.G.S.*

ie object of this is to show the relative agricultural value of the various ties, which can best be done by exhibiting the per-centage acreage of the rent crops. The numbers are obtained from the "Agricultural Returns" 869; the area of "woodland," and that of permanent pasture as divided een grass and hay, being added from the returns for 1871. The absolute bers vary slightly in different years, but the variation of the per-centage bers is very small. [For the results obtained from these maps and rams, *see* Journ. Roy. Agric. Soc., ser. 2, vol. vii., p. 268, 1871.]

251. Maps and **Table** illustrating **William Smith's** first ts towards producing his **Geological Map** of England.

The Geological Society of London.

.) Original table of the order of strata and their imbedded organic ins in the vicinity of Bath, as examined and proved by William Smith : to 1799. The MS. is in the handwriting of the Rev. B. Richardson, arley, who wrote it down from the dictation of William Smith, in the year

.) A geological map of the district around Bath, prepared by William th about the same period.

.) Smith's first small geological map of England.

These maps were presented by William Smith to the Geological Society ondon in the year 1831, on the occasion of his receiving at the hands heir president, Professor Sedgwick, their award of the Wollaston medal donation fund.)

252. Maps illustrating the rise and gradual progress of the of **Geological Surveying** in the British Islands and the onies. *The Geological Society of London.*

'm. Smith's first large geological map of England, published in the year i.

. B. Greenough's geological map of England, the first edition, published ie year 1819.

ain's first geological map cf South Africa.

ain's smaller geological map of South Africa.

ohn Phillips's geological map of Yorkshire, first edition.

arey's section across the Weald.

ection across the Weald by John Farey in 1806.

his horizontal section from London to Brighton, upon the scale of 1 inch mile, was constructed by John Farey in 1806. It was never published, several MS. copies were made of it. It is of great historical interest as g the first illustration of the anticlinal structure in the south-east of Eng-, of the truncated chalk escarpments, and of the proofs of enormous denu-on which must have taken place in the district.

252a. A Series of Indexes of Colours and Signs ployed in the Maps and Sections of the Geological vey of the United Kingdom.

he gradual advance of English geology (as expressed by maps) is shown me extent by the successive editions of the Index of Colours used by the logical Survey.

The earliest index (in MS. only) was drawn up by Sir Henry De la Beche, and shows the classification of rocks in use, and the extent to which geological surveying was carried in the year 1832.

In the first published index the volcanic rocks were indicated by green colours, but Sir R. I. Murchison, on becoming director-general in 1855, introduced the sytem of lettering the various formations, beginning with A for the Cambrian rocks, and altered the colouring of the igneous rocks to various shades of red. The results of these changes are shown on the second sheet.

In the index of colours published in 1856, the system of colouring, lettering, &c. then introduced will be seen to be essentially the same as that now in use. Various modifications have, however, since been made from time to time, for the purpose of representing the more numerous subdivisions of certain formations which it has become necessary to map, and some alterations have also been made in that part of the index which relates to the igneous and metamorphic rocks, so that the nomenclature of the maps of the Survey may approximate more closely to that of modern petrology.

3252b. Geological Map of Cornwall and West Devon. Ten Sheets on the scale of 1 inch to 1 mile, mounted together.

In this map the granitic masses of the S.W. of England are shown partly surrounded by Devonian rocks and partly by rocks of Carboniferous age, the latter overlying the Devonian rocks conformably, and filling up part of a synclinal trough, so that the Devonian rocks occupy superficial areas north and south of that composed of the Carboniferous rocks (culmseries). Dykes of Elvan (quartz-porphyry), which proceed from the underlying granite, are seen to trend in an east and west direction, while interbedded greenstones (rocks of a doleritic type, including beds of volcanic ash) follow the strike of the Devonian and Carboniferous rocks in various places. Masses of serpentine and diallage rock are likewise marked on the map, and also the tin, copper, iron, and lead lodes which occur in different localities, the stream-tin deposits being also indicated.

This map has a historical interest, since it is almost entirely the work of Sir Henry De la Beche, the founder and first Director of the Geological Survey of the United Kingdom. The publication of this map and the accompanying report on the geology of Cornwall, Devon, and West Somerset led to the recognition of the scientific and economic value and importance of a geological map of the country, to the institution of a Government geological survey under Colonel Colby, R.E., who was then Director of the Ordnance Survey, and afterwards to the foundation of the Museum of Economic Geology (now the Museum of Practical Geology), to illustrate the work of the Survey, and its practical application in mining, agriculture, architecture, and the fine arts. The Royal School of Mines was subsequently added, to afford facilities for the teaching of geology and the collateral sciences.

3252c. Geological Map of East Devon, Somerset, Dorset, and part of Wilts. (Scale, one inch to one mile.)

Ten sheets, on the scale of 1 inch to a mile, mounted together, illustrating not less than 53 formations in East Devon, Somerset, Dorset, and part of Wilts. The map includes the various tertiary beds of East Dorset, the chalk of Salisbury Plain and of Dorsetshire, including that of Ballard Down, together with the S.W. range of the Upper Greensand of Shaftesbury and Westbury, and to the west that of Black Down and Great Haldon.

The southern portion of the Jurassic formation in England forms a prominent feature in the map.

The Triassic Strata flanking the Mendips occupying extensive valleys between Watchet and Torquay.

The rocks composing the great anticlinal ridge of the Mendip Hills mark the boundary of the Somersetshire coal-field, which here is generally concealed by Triassic, Liassic, and Oolitic overlying formations; when, however, the coal measures are exposed, the coal seams are indicated by continuous black lines; these lines, when broken, show the extension of the seams beneath the overlying deposits. In the S.W. portion of the map the Devonian rocks of Totnes, Torquay, and Start Bay are shown, and also the Carboniferous and Devonian rocks of Mid Devon, and the easternmost portion of the granite of Dartmoor.

3252d. Geological Map of the Wealden Area.

In addition to the Wealden area, this map comprises the southern and main parts of the London Tertiary Basin and the eastern portion of the Hampshire Basin, which are separated from each other by the intervening parallel range of chalk hills, commonly known as the North and South Downs respectively.

The upper and lower cretaceous rocks, from the Upper Greensand to the Lower Greensand inclusive, appear in succession from beneath the chalk, forming an outer margin surrounding the Wealden area, which is separated from the central portion, consisting of the alternations of sand and clays (called the Hastings Beds), by the Weald clay, a broad belt of low and generally flat ground.

The model constructed by Messrs. Topley and Jordan (No. 3248) will convey a better notion to the eye of the general configuration of the ground than can be afforded by the map.

The latter, however, shows the undulations of the chalk, which forms large synclinal and anticlinal folds or elevations and depressions, and the enormous amount of cretaceous strata which once extended over the space between the North and South Downs, and which must have been removed by denudation.

3252e. Geological Map of North Wales, on the scale of one inch to a mile.

The rocks consist of the Cambrian and Lower Silurian strata, from the bottom of the Menevian beds to the top of the Bala beds, including the Bala limestone, with associated eruptive rocks and contemporaneous lavas and ashes, also of Upper Silurian strata of the Wenlock series, and of Old Red Sandstone, Carboniferous Limestone, Coal Measures, and Permian beds.

In Anglesea, the Cambrian rocks consist of grits and gneiss, and the Silurian strata of the island are also partly gneissic and associated with granite rocks. In Carnarvonshire, the Cambrian rocks largely consist of grits and purple slates, which are extensively quarried for slate, especially at Llanberis and Penryhn. In Merionethshire, the same formations consist chiefly of massive purple and green grits, with a little purple slate. The contemporaneous volcanic series occurs at the top of the Arenig, and also in the Bala series, the top of Snowden being a calcareous volcanic ash contemporaneous with the Bala limestone. Most of this series is fossiliferous.

The Upper Silurian beds consist of the Denbighshire flag-stones and Wenlock shales, also fossiliferous.

The Old Red Sandstone (unfossiliferous) is sparingly developed in Anglesea and Denbighshire. The Carboniferous Limestone and overlying mill-stone grit and Coal Measures are shown in Anglesea, Denbighshire, and Flintshire, and these are in places succeeded by red Permian strata and by the New Red series.

3252f. Geological Map of Mid Wales, on the scale of one inch to a mile.

This map contains 17 quarter sheets, on the scale of one inch to one mile. It comprises part of the Silurian rocks of Wales, and the Old Red Sandstone of Herefordshire and Shropshire. Rocks of Lower Silurian age occur in the western portion of the district, the north-western area displaying intrusive and interbedded igneous rocks. To the S.E. there is a succession of beds of Upper Silurian and Old Red Sandstone age, while to the N.E. Lower Silurian rocks crop out, together with a small exposure of the Cambrian rocks in the neighbourhood of Church Stretton. A portion of the Shropshire coal-field is included in the N.E. part of the map, and also the overlying Permian and Triassic formations of Shrewsbury. The localities where lead ores occur are indicated by the usual symbols.

3252g. Geological Map of the Midland Counties, N.W. Division.—Six sheets on the scale of one inch to one mile, mounted together.

The Carboniferous Limestone of Derbyshire, coloured pale blue on the map, occupies almost the central portion. The interbedded basalts (Toadstones) are shown, and also the metalliferous lodes (mostly lead ores).

This tract is traversed by the Pennine anticlinal axis from which the strata dip away to the east and west, the Yoredale Shales, Sandstones, and Limestones, and the Coal Measures, appearing successively on either side. To the eastward these form the Nottinghamshire and Yorkshire coal-fields, and are overlaid by Magnesian Limestone, Permian, and various Triassic strata, but they are cut off to the westward by the boundary fault, which running nearly N.N.W. brings the Carboniferous Limestone against the Trias. Near Stockport the Coal Measures reappear as the continuation of the Lancashire coal-field, and further south, near Congleton and Newcastle-under-Lyne in the N. Staffordshire coal-field, south of the limestone tract, the Carboniferous rocks are concealed by Triassic marls, but they reappear in the Leicestershire coal-field, part of which is seen in the S.E. corner of the map. Towards the west a large area is occupied by the Triassic Marls of Cheshire, in which extensive deposits of rock salt occur.

3252h. Geological Map of the Midland Counties, S.E. Division.—Six sheets, on the scale of one inch to one mile, mounted together, illustrating the geology of the whole or parts of nine counties in central England.

The Oolitic rocks cross the map diagonally from N.E. to S.W. The spots where the Northamptonshire iron ores have been worked are indicated on the map. Towards the S.E. these limestones and sandstones are succeeded by the Oxford Clay, which, after forming the flat districts around Huntingdon and Bedford, passes beneath a second escarpment of the Cretaceous rocks, running roughly parallel to the first. A small portion of the Lower Tertiaries of the London basin occurs in the S.E. corner of the map. To the N.W. of the Oolitic feature the Lias and Trias form the broad undulating country of Leicestershire, while in the N.W. corner of the map a great part of the Warwickshire and Leicestershire coal-fields are shown.

3252k. Geological Map of the Lancashire Coal-field, scale six inches to one mile.

The area comprised in the sheet includes on the north Preston and Burnley, and on the south St. Helens and Manchester.

The principal coal seams of the district are shown, and also the great line of fault which disturb the coal-bearing strata. The Roman rocks, New Red

Sandstone, and horizontal sections, on the scale of six inches to one mile (for height and distance) illustrate the sheet. One showing the Dukenfield Colliery and the various seams of coal through which the shaft is sunk ; the other, the structure of the Manchester coal-field and adjoining country. A vertical section, on a scale of 40 feet to an inch, of the Lancashire and Cheshire coal-fields, shows the various seams of coal worked at Dukinfield and other collieries, and the relative thickness of the sandstones, shales, and other strata connected with them..

Horizontal and vertical sections descriptive of the Yorkshire coal-field are also shown.

3252l. Geological Map of a portion of the Yorkshire Coalfield (on the scale of six inches to the mile); the topography by the Ordnance Survey, the geology by the Geological Survey of England and Wales.

The geological formations shown on the map are (top) Magnesian Limestone (blue), Middle Coal Measures (black), Lower Coal Measures (pale black), Millstone Grit (still paler black) ; in the Coal Measures and the Millstone Grit thick beds of sandstone are denoted by yellow and other colours spread over the general black tint; the positions of faults at the surface are shown by white lines, and where faults have been proved in workings, their corresponding positions in beds of coal are denoted by yellow lines; black lines are the outcrops of coal seams. The depths of collieries, and where possible the thickness of the coals passed through, and sundry other geological and mining details, are engraved on the maps. In looking at the map it must be borne in mind that its object is to show what rock it is that forms the surface at each spot, and that the fact that the surface at different spots is formed of different rocks is owing to the inclination of the strata. If the beds lay flat, we should have the same rock extending over nearly all the area. But the beds do not lie flat; over a great part of the country they slope or dip in a general way from south-west to north-east. In consequence of this dip the lowest beds, Millstone Grit, come up to the surface at the south-west corner; as we go thence in a north-easterly direction the Millstone Grit passes away underground and is covered up by the Lower Coal Measures ; these in their turn are carried down and hidden beneath the Middle Coal Measures. The dip is steepest on the south-west, and decreases towards the north-east till the beds become flat and at last turn up and begin to dip towards the south-west, so that the measures, as far as we can see them, lie in a basin. How far towards the east this basin extends we cannot say, because, soon after the change of dip occurs, the Magnesian Limestone comes on and hides the Coal Measures from view. Besides the rocks mentioned the flats of alluvial river-muck and gravel are distinguished by a pale straw colour; old river gravels, deposited when the rivers flowed at a higher level than now, by a reddish brown tint ; and some few patches of Boulder Clay and Gravel by stippling.

3252m. Index Geological Map of Wales, scale four miles to one inch, being a reduction of the one inch Geological Survey map of the same district.

Vertical section of the Purbeck strata of Dorsetshire.
Vertical section of the Tertiary strata of the Isle of Wight.
Horizontal sections of the Isle of Wight.
Horizontal sections of Dorsetshire coast, &c.

3252n. Geological Survey Map of Ireland, scale one inch to one mile.

The Geological Survey map of Ireland shows the state of progress to the present time. The coloured maps are published, those uncoloured are in various stages of progress, while the northern portions of Ireland have yet to be geologically surveyed.

The map shows the central plain of Ireland formed of Carboniferous Limestone (coloured blue), having on the south the Galty, Commeragh, and other mountains, formed of Lower Silurian and Old Red Sandstone, rising to elevations of over 3,000 feet. Along the east are the gigantic Silurian mountains of Wicklow, reaching in Suguaquillia a height of 3,039 feet, and on the west are "the Western Highlands" of Mayo and Galway, consisting of granite, quartzite, schist, and other metamorphic rocks of Lower Silurian age, in the midst of which are Upper Silurian beds on both sides of Killary Bay. To the extreme south-west are the mountains and promontories of Kerry, formed of Old Red Sandstone, with some Upper Silurian beds at Sybil Head and Smerwick Bay. Carntual, near Kilkenny, reaches an elevation of 3,404 feet, being the highest point in Ireland. Small coal basins (tinted dark), resting on flagstones and shales representing the Millstone Grit series, occur in counties Cork, Tipperary, Kilkenny, Leitrim, and Tyrone.

3252c. Drawings illustrative of the Microscopic Structure of various English Eruptive Rocks, by Frank Rutley. *Geological Survey of England and Wales.*

1. Micaceous Felstone, × 37. Potter Fell, Long Sleddale, Westmoreland.

This rock is one of the numerous dykes which occur in the Upper Silurian rocks of the lake district, and may be regarded as a good typical example of very many of them. It consists of crystals of Orthoclase and magnesian mica embedded in a felsitic matrix. A little Magnetite is also present. Of the different component minerals, only a few of the Felspar crystals are sufficiently large to be apparent to the naked eye. The mineral components of these dykes are the same as those of Minette, but the former rocks differ from the latter in containing less magnesian mica, and in some of the Orthoclase being well crystallized.

1*a*. Key to Fig. 1.

2. Devitrified Pitchstone Porphyry, × 25. Stoke Lane, Mendips, Somersetshire. In this section crystals of both orthoclastic and plagioclastic felspars are shown, containing some Viridite, and surrounded by the devitrified magma which characterises this rock.

2*a*. Chromo-lithograph of Fig. 2, by Messrs. Vincent Brooks, Day, and Son.

3. Dolerite, × 75. Charfield Green, 150 yards north of Railway Station, Gloucestershire.

The larger drawing shows a much altered crystal of Orthoclase, as seen by polarized light, exhibiting twinning upon the Carlsbad type. Several of the larger crystals which occur in this rock, but which are not shown in the drawing, may also be Orthoclase, while some of the smaller ones appear to be Plagioclase greatly altered. Pseudomorphs after Olivine are also plentiful in the rock, and the smaller drawing represents one of them.

3*a*. Chromo-lithograph of Fig. 3, by Messrs. Vincent Brooks, Day, and Son.

4. Basalt, × 50. Damery, Gloucestershire.

Composed of Plagioclase, altered Augite, and serpentine pseudomorphs, some possibly after Olivine and Magnetite.

4*a*. Chromo-lithograph of Fig. 4, by Messrs. Vincent Brooks, Day, and Son.

5. Minette, × 37. Near first Railway Bridge from Windermere Station, Westmoreland.

In this section crystals of magnesian mica are shown lying in a felsitic matrix.

6. Diabase, × 25. Knowles Hill, Newton Bushel; Devonshire.

This rock is mainly composed of an altered triclinic Felspar, Augite, Chlorite, Serpentine Quartz, and Pyrites apparently altered in places into Limonite. A little Apatite is also present. In the drawing the upper half of the field represents the section by ordinary illumination, while the lower half shows the remaining portion as seen by polarized light.

7. Minette, × 150. Washfield, three miles N.W. of Tiverton, Devonshire.

A much decomposed Minette, full of small cavities, which cause it to resemble a scoriaceous lava, but when examined microscopically many of these holes are seen to present definite hexahedral forms, from which no doubt crystals of mica have been removed. The black granules and crystals represent Magnetite in some, if not in all, instances. The matrix is felsitic.

8. Microscopic drawings illustrative of structure in some of the eruptive rocks of Somersetshire, Fig. 1, volcanic breccia × 25. Wrington Warren, near Bristol. Section etched with acid and drawn as seen by reflected light. The upper portion of the field represents part of a small fragment of fossiliferous limestone (showing crinoid remains).

Fig. 2. Portions of crinoid stems from one of the above limestone fragments, × 105.

Fig. 3. Doleritic matrix in which the above limestone fragments are imbedded, × 50.

Fig. 4. Crystals of Magnetite in Felstone, × 150. Near Downhead, Mendips.

Fig. 5. Amygdaloid in Dolerite, × 25. Uphill Cutting, Great Western Railway.

Fig. 6. Amygdaloid of Calcspar in Dolerite, × 45. Uphill Cutting, Great Western Railway.

8a. Mechanical autotype of Plate 8, by Messrs. Vincent Brooks, Day, and Son.

9. Microscopic drawings illustrative of structure in some of the eruptive rocks of Somersetshire.

Fig. 1. Pseudomorph after Augite, from Dolerite, × 175. Uphill Cutting, Great Western Railway.

Fig. 2. Outline of an Augite crystal (natural size), given for comparison with preceding figure.

Fig. 3. Plagioclase from Doleritic matrix of Volcanic Breccia. Wrington Warren, near Bristol.

Fig. 4. Ditto, showing banding by polarised light, × 100.

Fig. 5. Pseudomorph after Augite, from Dolerite, × 175. Uphill Cutting, Great Western Railway.

Figs. 6, 7, and 10. Calcareous bodies in Volcanic Breccia. Wrington Warren, near Bristol.

Fig. 8. Crystal of a Felspar in diversified Pitchstone Porphyry. Stoke Lane, Mendips.

Fig. 9. Calcspar Amygdaloids in Dolerite, × 50. Uphill Cutting, Great Western Railway.

Fig. 11. Crystal of Titaniferous Iron from Felstone, × 350. Near Downhead, Mendips.

Fig. 12. Fragment of Volcanic Breccia (natural size). Wrington Warren, near Bristol.

The matrix is Doleritic, the imbedded fragments are Fossiliferous Limestone, probably of Carboniferous age.

Figs. 13 and 14. Magnetite crystals in Felstone, × 350. Near Downhead, Mendips.

9a. Mechanical Autotype of Plate 9, by Messrs. Vincent Brooks, Day, and Son.

b. Maps, Diagrams, &c.

COLLECTION OF MAPS AND SECTIONS LENT BY THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND.

3253a. Geological Map of the Keswick District, on the scale of six inches to the mile, with appended one-inch maps, sections, &c. *J. Clifton Ward.*

With this are exhibited three one-inch maps of the same district, one of which serves as a coloured index sheet to the large map, and shows the varied dips of the strata, while the other two serve as cleavage and glacial maps. Also a horizontal section at the foot of the large map on the six inch scale, ten horizontal sections on the one-inch scale, a section through the plumbago mine in Borrowdale, and twenty-four chromo-lithographic figures of the microscopic structure of rocks of the district.

3253b. One-inch quarter-sheet, 101 S.E. of the Ordnance Survey (Keswick District), converted into a **Geological Model** by Mr. Jordan, showing the various geological divisions, dips, faults, and mineral veins. *J. Clifton Ward.*

The work here embodied is the result of the labours of the contributor as an officer of the Geological Survey, but the colouring of the model has been privately undertaken with a view to its presentation to the Keswick Museum of Local Natural History

3253c. One-inch sheet, 101 S.E. of the Ordnance Survey (Keswick District), converted into a **Model,** by Mr. Jordan, showing ice-scratches, boulder-transportation, and old lake-beds. *J. Clifton Ward.*

Prepared by the contributor for the Keswick Museum of Local Natural History

3253d. Diagrams of **Microscopic Rock-structure;** photographs, coloured and uncoloured, enlarged from small water-colour drawings $1\frac{1}{4}$ inches in diameter, made direct from the microscope. *J. Clifton Ward.*

The photographs have been taken by the firm of Hennah and Kent, of Brighton, from small water-colour drawings made by the contributor, direct from the microscope, and $1\frac{1}{4}$ inches in diameter.

A. Spherulitic felsite, Carrock Fell, Cumberland.
B. Hypersthenite, Carrock, Cumberland.
C. Fine grained band in Hypersthenitic rock, Carrock Fell.

Three uncoloured photographs, also taken from small water-colour drawings made by the contributor

D. Chiastolite slate, Skiddaw, Cumberland.
E. Quartz felsite, St. John's Vale, Cumberland.
F. Skiddaw Slate, passing into quartz felsite, St. John's Vale, Cumberland.

The small coloured drawings from which these photographs have been taken, are (except in the case of D) also exhibited (*see* Plate C).

3253e. Coloured Diagrams enlarged from small water-colour drawings, 1¼ inches in diameter, made direct from the microscope by the contributor. *J. Clifton Ward.*

A.—*Cumberland Volcanic Rocks* (see also Plate A of small water-colour drawings contributed).

1. Lava, Brown Knotts, Keswick.
2. Lava, Wastwater. (Polarized light.)
3. Felsite, amid altered ash, Bleaberry Fell, Keswick.
4. Ash, Steel Fell. (Polarized light.)
5. Altered streaky ash, Base Brown.
6. „ „ (Polarized light.)
7. Altered ash, Hart Side.
8. Highly altered fine bedded ash, Great Gable.

B.—*Welsh Volcanic Rocks.*

9. Felstone, a metamorphosed ash, Rigghause End, Vale of St. John, Cumberland. (Polarized light.)
10. Felstone, Aran Mowddwy. Also represents the structure of Fig. 9. when viewed with plain light.
11. Felstone, Aran Mowddwy. (Polarized light.)
12. Felstone, Aran Benlynn.
13. Felstone, Llanberis Route, Snowdon.
14. Slaggy felstone or altered streaky ash, Llanberis Route, Snowdon.

NOTE.—The Welsh felstone probably represents the modern trachytes or quartz-trachytes, and the Cumberland lavas the modern trachy-dolerites and basalts.

3253f. Three Plates of small water-colour drawings, 1¼ inches in diameter, made direct from the microscope by the contributor, illustrating **Microscopic Rock-structure.**
J. Clifton Ward.

A.—*Modern Volcanic Rocks.*

1. Trachyte, Solfatara, x 40.
2. „ „ (Polarized light), x 15.
3. Leucitic lava of 1631, Vesuvius, x 15.
4. „ „ Alban Mount, Rome, x 14.
5. „ „ „ „ (Polarized light).
6. Lava of 1794, Vesuvius, x 6.
7. „ „ x 45.

Ancient Cumberland Volcanic Rock.

8. Lava, Eycott Hill, x 25.
9. „ Brown Knotts, Keswick, x 30.
10. „ near Wastwater. (Polarized light), x 15.
11. Felsite, amid altered ash, Bleaberry Fell, Keswick, x 60.
12. Ash, Steel Fell. (Polarized light), x 15.
13. Altered streaky ash, Base Brown, x 15.
14. Altered ash, Hart Side, x 20.

B. *Illustrating the Metamorphism of Volcanic Rocks around the Granites of Eskdale and Shap.*

1. Altered ash, Yewbarrow, x 50.
2. Altered contemporaneous trap (?) close to granite, x 50.
3. Same field of view, in polarized light, x 50
4. Highly altered ash, close to granite. (Polarized light), x 50.
5. Bastard granite. (Polarized light), x 50.
6. True granite, x 50.
7. Junction of highly altered ash with Shap granite. (Polarized light x 25.

C.

1. Altered Skiddaw slate passing into quartz felsite, Clough Head, St. John's Vale, x 30.
2. Quartz felsite, St. John's Vale, x 30.
3. Altered Skiddaw slate, Red Pike, x 70.
4. „ „ Buttermere, x 70.
5. Syenitic granite, Scale Force, Buttermere, x 30.
6. Spherulitic felsite, Carrock Fell summit. (Polarized light), x 10.
7. Hypersthenite, White Crags, Carrock. (Polarized light), x 10.
1. Fine-grained band in hypersthenite. (Polarized light), x 10.

3253g. Plates illustrative of **Structures in Felspars, Leucite, Obsidian,** and **Perlite,** from drawings made partly in pencil, partly in lamp-black, by Frank Rutley, F.G.S., H.M. Geological Survey. Plates I. and II. illustrate a paper in the Quart. Journ. of the Geological Society of London for Aug. 1875 Plates III. and IV. illustrate a paper in the Royal Microscopical Society's Transactions, March 1876.

Frank Rutley, Geological Survey Office.

PLATE I.

Fig. 1 Orthoclase, Arendal, showing crystals arranged in two directions, other than those of striation × 50 (polarized light)
2. Felspar crystal in perlite, Schemnitz, Hungary, showing partial cross-hatching × 55 (polar.)
3. Crystal in trachyte, Berkum, near Bonn, Rhine, showing internal curved divisional markings, with lines crossing at right angles in the lateral areas × 115 (polar.).
4. Partially formed, or partially disintegrated crystal in obsidian, Mexico × 175 (dark ground illumination).
5. Patches of cross-hatched felspar in oligoclase, Twedestrand, Norway × 115 (polar.).
6. One of the above patches, showing partial cross-hatching. × 350 (polar.)

PLATE II

Fig. 1. Minute crystal in obsidian, Mexico. × 240.
2. Diagrammatic exaggeration of the above.
3 Crystal from trachyte, Berkum, Rhine. × 90 (polar.).
4. Crystal from basalt, Cleveland, showing rectangular banding and subordinate oblique striation, the latter possibly indicating planes connected with twinning on the Baveno type. × 45 (polar.).
5. Crystal in obsidian, Mexico. × over 100.

6. Crystals of plagioclase in gabbro, Volpersdorf, Silesia, showing bands at right angles. × 90 (polar.).
7. Crystal in basalt, Cleveland, Yorkshire. × 45 (polar.).
8. Fragment of plagioclase in basalt, Cleveland, showing alternately dark and light bands fringing an obliquely cut twin lamella, as in fig. 10. × 45 (polar.).
9. Crystals on edge of section of basalt, Cleveland, showing cross-hatched striation and a rectangular cleavage at *x* on the outer edge of the section. × 45 (polar.).
10. Diagrammatic vertical section through a section of plagioclase, cut obliquely to the twinning planes; the spaces marked *w* would alternately appear light and dark in different positions of the Nicols when seen by polarized light, the overlap of the complementary colours giving rise to white light.
11. Diagrammatic section similar to fig. 10, but cut more obliquely to the twinning planes, so that, instead of coloured bands separated by light or dark ones, an unbroken surface of white light might result, although the section might be that of a felspar many times twinned.

PLATE III.

Figs. 1, 4, 5, 6, 7. Structures seen in a thin section of spherulitic obsidian from the lava stream of Rocche Rosse, in the Isle of Lipari.
8. Portion of one of the spherulitic bands in the above rock. × 22.
12. Magnetic crystals partially converted into peroxide of iron, occurring in a crystal of leucite from Vesuvius. × 760.
2, 3, 9, 10, 11, 13, 14. Structures seen in a crystal of leucite, from Vesuvius.

PLATE IV.

Structure in perlite, from Buschbad, near Meissen, showing the spheroidal structures lying between divisional straight lines F. F. F. F.

3253. Map showing the work of the **Geological Survey** of **Scotland,** on the scale of one inch to the statute mile. All the published sheets of the map are given here, and a few of which the survey is completed, but which are not yet engraved, are inserted in MS. At the foot of the map an example of the horizontal sections is given which are run across the country on the scale of six inches to the statute mile.

Geological Survey of Scotland, Prof. Geikie, F.R.S., Edinburgh, Director.

3254. Geological Map of the Ayrshire coal-field and adjoining districts, on the scale of six inches to the statute mile. This map has been selected as an illustration of the detailed work of the Geological Survey of Scotland. The whole county is surveyed on this scale, though only the mineral districts are published on these maps, the general map of the country (*see* No. A.) being on the scale of one inch to a mile. At the foot of the map a MS. sheet is inserted to show the stages of progress in the field work of the survey. Two specimens are likewise given of the detailed vertica

sections, on the scale of forty feet to the inch, which are published in illustration of the coal-fields.

Geological Survey of Scotland, Prof. Geikie, F.R.S., Edinburgh, Director.

3254a. Geological Map of **England and Wales,** by the late Sir Roderick I. Murchison, Bart., K.C.B., &c. Fifth edition, with all the railways. Scale, 28 miles to an inch ; size, 14 inches by 18. *Edward Stanford.*

3254b. Geological Map of **Ireland,** by Joseph Beete Jukes, M.A., F.R.S., late Director of H.M. Geological Survey of Ireland. This map is constructed on the basis of the Ordnance Survey, and coloured geologically. It also shows the railways, stations, roads, canals, antiquities, &c., and when mounted in case forms a good and convenient travelling map. Scale, 8 miles to 1 inch ; size, 31 inches by 38. *Edward Stanford.*

3254c. Geological Map of **London** and its Environs. Scale, 1 inch to a mile ; size, 24 inches by 26. Compiled from various authorities by J. B. Jordan, Esq., of the Mining Record Office, and printed in colours exhibiting the superficial deposits. It includes Watford on the north, Epsom on the south, Barking on the east, and Southall on the west, and shows the main roads in and around the Metropolis, the railroads completed, and the sanctioned lines. *Edward Stanford.*

3254d. Geological Map of **Canada** and the adjacent regions, including parts of the other British provinces and of the United States, by Sir W. E. Logan, F.R.S., &c., Director of the Geological Survey of Canada. Scale, 25 miles to an inch ; size, 102 inches by 45. *Edward Stanford.*

3254e. Geological Map of **India.** General sketch of the physical and geological features of British India, by G. B. Greenough, Esq., F.R.S. With tables of Indian coal-fields, minerals, fossils, &c. Scale, 25 miles to an inch ; size, 68 inches by 80. On nine sheets. *Edward Stanford.*

3254f. Geological Map of the **World,** by Jules Marcou. Constructed by J. M. Ziegler. Size, 72 inches by 50. *J. N. Ziegler.*

3254g. Geological Sketch Map of **South Africa,** from personal observations (combined with those of Messrs. A. G. Bain, A. Wylie, T. Bain, jun., Dr. Atherstone, and R. Pinchin, in Cape Colony, together with those of Dr. Sutherland in Natal, and of Mr. E. Button), north of 24° latitude. Scale, about 35 miles to an inch ; size, 33 inches by 28. *E. J. Dunn.*

2. Maps, Diagrams, Fossils, &c., exhibited by various Contributors.

3255. The Contours of London and its **Environs.** Plain and coloured geologically.

176 square miles, scale $\frac{1}{17032}$, 1856. *R. W. Mylne, F.R.S.*

3256. London and its **Environs Topographical** and **Geological.**

131 square miles, scale $\frac{1}{17032}$, English and French geological references, 1855. *R. W. Mylne, F.R.S.*

3257. Section of a **Well** at the **Hampstead Road,** showing detail depths of strata, 1840. *R. W. Mylne, F.R.S.*

3258. Five Outline Sections of the strata under **London,** with a block index plan, 1850. *R. W. Mylne, F.R.S.*

3259. Topographical and **Geological Map** of **London** and its environs.

100 square miles, scale 1·43 inch to a mile, 1851.
R. W. Mylne, F.R.S.

3260. Geological Map of **London** and its **Environs.**

159 square miles, scale 1·43 inch to a mile, with a longitudinal section of 18¼ miles, 1871. *R. W. Mylne, F.R.S.*

3261. Geological Map of the **London** and **Paris Basins.**

The tertiary and cretaceous districts of England and the north of France, Belgium, Holland, and Denmark.

The coalfield areas and contoured depths of the adjacent seas, 1862. *R. W. Mylne, F.R.S.*

3262. Map of the Bristol Coalfields and country adjacent, geologically surveyed by William Sanders, F.R.S. (In nineteen sheets.) *Bristol Museum and Library.*

The area of the map is 720 square miles. The topographical basis consists of a reduction to the scale of 4 inches to the mile of 218 parish maps. The geological lines are entirely the result of the author's personal surveys; about 20 years were devoted to the work. The map was published, in 1864, at the author's cost.

A reduced copy, on the scale of 1 inch to the mile, in one sheet, was published in 1873.

3264. A Geological Map of the British Isles, by Professor John Phillips, F.R.S. *Thomas Burt.*

3265. Geological Map of the Arctic Regions.
C. E. De Rance, F.G.S.

The topography is taken from the Chart accompanying the Admiralty correspondence connected with the British Arctic Expedition of 1875. The geological boundaries of the Parry Islands, and north coast of America, from the determination by Conybeare, Murchison, Salter, and Dr. Haughton; of the specimens brought back by the expeditions of Franklin, Parry, Back, John and James Ross, Sabine, Buchan, Beechey, Sherard Osborn, and M'Clintock. Those of West Greenland from the observations of Giesecké, Nordenskiöld, O. Heer, and Dr. Brown. Those of East Greenland and Spitzbergen from the results of the various Austrian, Swedish, and North German expeditions. Those of Hall Basin, and the channels lying north of Smith's Sound, from the labours of Drs. Kane and Bessels, which prove that the upper Silurian rocks, noticeable along the southern fringe of the Arctic Archipelago, reappear in this tract, the Lower Carboniferous Coal-bearing Sandstones, and overlying Carboniferous Limestones, lying in a basin.

3266. Maps, illustrative of theories of relative directions of lodes, joints, mountain chains, coast lines, limits of geological formations and rivers. *Jos. P. O'Reilly, Dublin.*

Map of Europe (geographical); two base lines, viz., Algerian coast and Syrian coast lines.

Map of Spain (Francisco Coello's geographical); base line taken from the map of Europe (Compare with de Verneuil's map for correspondence of geographical and geological lines of direction.)

Alpine Club Map of Switzerland; two base lines from globe, east coast of Sardinia and south-east coast of Red Sea.

Jukes's geological map of Ireland; base line, eastern coast of Adriatic.

The base lines are portions of great circles having the directions of, and passing along, the coast lines indicated, and have been transferred from the globe.

3267. Model of the Cleveland Hills and district showing the outcrop of the main seam of Ironstone.
John Bell, Saltburn-by-Sea.

3268. Geological Maps and **Model** of **New Zealand.**

1. Copy of the first geological map of the whole of New Zealand, prepared by Dr. Hector, and exhibited at the New Zealand Exhibition in 1865. This map was engraved by the Geological Department and published in 1869.

2. Geological sketch-map of New Zealand constructed from the official surveys of the Geological Department by James Hector, C.M.G., M.D., F.R.S., &c., director of the Governmental Geological Surveys, Wellington, 1873.

3. Relief-model of New Zealand on same scale as the Geological map (2), and with a vertical scale four times as great as that of the horizontal. This model is placed beside the geological map to illustrate the forms of the surface of the parts of country occupied by the different geological formations. Modelled by Dr. Hector, 31st March 1876. *James Hector, C.M.G., M.D., F.R.S.*

3268a. Geological Map and sections of a part of the Province of Koutais, published by the "Administration des Mines," 1873. *Mining Institute of St. Petersburg.*

3268b. Geological Map of a part of the Province of Bakou, published by the "Administration des Mines," 1872. *Mining Institute of St. Petersburg.*

3268c. Geological Map of Russia in Europe, begun in 1868 by the Members of the Mineralogical Society of St. Petersburg. *Mining Institute of St. Petersburg.*

3268d. Geological Map of the mining district of Outka, in the Oural, by M. Valérien de Moeller, 1875. *Mining Institute of St. Petersburg.*

3268e. Geological Map of the mining district of Ilim, in the Oural, by M. Valérien de Moeller, 1875. *Mining Institute of St. Petersburg.*

3268f. Sections of the mining districts of Ilim and Outka, in the Oural, by M. Valérien de Moeller, 1875. *Mining Institute of St. Petersburg.*

3268g. Geological Map of the southern part of the Province of Nijnii Novgorod, by M. Valérien de Moeller, 1875. *Mining Institute of St. Petersburg.*

3268h. Geological Map of the Province of Wladimir, by M. Dittmar. *Mining Institute of St. Petersburg.*

3268i. Geological Map of Russia in Europe and the Oural mountains, executed by Murchison de Verneuil, and Keyserling, and completed up to 1870 by M. Helmersen. *Mining Institute of St. Petersburg.*

3268j. Geological and Industrial Map of the western portion of the carboniferous district of Donetz, by Messrs. An. and Al. Nossow, 1873. *Mining Institute of St. Petersburg.*

3268k. Geological Map of the carboniferous district of the country inhabited by the Cossacks of the Don, executed by Messrs. Antipon Teltonochkine and Wassiliew, 1866–69. *Mining Institute of St. Petersburg.*

3268l. General Geological Map of the carboniferous district of Donetz, executed under the direction of M. Helmersen, 1871. *Mining Institute of St. Petersburg.*

3268m. Geological Map of the southern portion of the Oural chain, by Messrs. Meglitsky and Antipon, 1855. *Mining Institute of St. Petersburg.*

3268n. Geological Map of the western slope of the Ourals, by M. Valérien de Moeller. *Mining Institute of St. Petersburg.*

3268o. Geological Map of the Province of Kherson, by M. Barbot de Marny. *Mining Institute of St. Petersburg.*

3268p. Geological Map of the Province of Kiew, by M. Theophilaktow, 1872. *Mining Institute of St. Petersburg.*

3268q. Geological Map of the Town of Kiew, by M. Theophilaktow, 1874. *Mining Institute of St. Petersburg.*

3268r. Geological Map of the Province of Twer, executed by Messrs. Lahousen and Dittmar.
Mining Institute of St. Petersburg.

3268s. Geological Map of a part of the Province of Erivan, published by the "Administration des Mines."
Mining Institute of St. Petersburg.

3268t. Geological Map of the Province of Elisavetpol, published by the "Administration des Mines," 1869.
Mining Institute of St. Petersburg.

3268u. Geological Map of a part of the Province of Koutais, published by the "Administration des Mines," 1874.
Mining Institute of St. Petersburg.

3268v. Geological Map of the Province of Nowgorod, by M. Lahousen. *Mining Institute of St. Petersburg.*

3269. Agricultural Map of Belgium.

(*a.*) Geology and mining. Geological models, horizontal and vertical sections.

(*b.* and *c.*) This map shows, by means of colours and signs, the mineral constitution of the soil of Belgium, based on the geological data, and the different kinds of cultivation. The agricultural land is divided into regions, and the latter into zones.

(*d.*) Height, $0 \cdot 45^{m}$; width, $0 \cdot 50^{m}$.

C. Malaise, Professor at the Government Agricultural Institute at Gembloux (Province of Namur, Belgium).

3270. Illustrations of the **Sub-Wealden Boring,** at **Netherfield,** near **Battle, Sussex.**

Contributed on behalf of the Sub-Wealden Exploration Committee, by Henry Willett, F.G.S. and W. Topley, F.G.S.

The Sub-Wealden boring was commenced in 1872, with the view of ascertaining the order and thickness of the secondary rocks beneath the south-east of England, and of determining, if possible, the depth and age of the Palæozoic rocks which are

believed to underlie them. Geologists have for some years believed, chiefly in consequence of a paper published by Mr. R. Godwin-Austen in 1856, that beneath the secondary strata of the south-east of England there exists a floor of Palæozoic rocks, prolonged from South Wales, Gloucestershire, and Somersetshire on the west, and from Belgium and the north of France on the east. Amongst these Palæozoic rocks there is a possibility that coal-measures may occur; coal, in fact, is now worked beneath the Oolites in Somersetshire, and beneath the Cretaceous rocks in the north of France. It is only in this subordinate sense that the Sub-Wealden boring can be described, as it sometimes has been, as a "search for coal." The primary object is to learn what rocks underlie the Weald, this being a point of high scientific interest.

Such were the problems presented for solution. The methods employed and the results obtained are as follows:—A committee of reference was formed in London, with Prof. A. C. Ramsay as chairman; Mr. H. Willett, of Brighton, has throughout acted as hon. sec. and treasurer. The money has been mainly raised by private subscription, aided by grants from the Government, the Royal Society, and the British Association. Two borings have been made; the first was abandoned at a depth of 1,030 feet, owing to an accident to the rods. The second boring was commenced in Feb. 1875, and is now (in March 1876) 1,903 feet from the surface.

The specimens exhibited are arranged in two series; those on the top and second shelves are examples of fossils from the Kimeridge Clay, named by Mr. Etheridge. Those on the lower shelves are arranged in order of depth, the ends nearest the surface being placed on the left hand side of the bottom shelf; the examples in this series are mainly from the second boring, but a few specimens are added from the first boring—these are marked as such.

The work is performed by the Diamond Rock-boring Company. The rock is bored by a rapidly revolving "crown" set with diamonds; the débris are carried up to the surface by a stream of water which is forced down the hollow boring-rod. The "core" of rock rises within the enlarged space, or "core-tube, at the bottom of the rods; it is thus preserved, and is afterwards drawn to the surface. The machinery employed is shown in the photographs; an example of the boring "crown" is placed on the bottom shelf of the case; specimens of long "cores" extricated in solid masses as here shown are placed by the side of the case.

The second boring commenced with a hole 8 inches in diameter, yielding a 7-inch core; this was gradually reduced, owing to the necessity of lining the hole, until, at 1,670 feet, it was reduced to a 2-inch hole, yielding a 1-inch core.

The long diagram gives a detailed section of the strata passed through in the second boring, which may be grouped as follows:—

		Thickness.	Depth from Surface.
Purbeck Beds - -	Shales, limestones, cement-stones, and gypsum - - -	200 -	—
Portland Beds - -	Sandstone - - - -	57 -	257
Kimeridge Beds -	A variable set of strata; chiefly shales, and cement stones in the upper part, with many beds of sandstone and limestone in the lower part - -	1,512 -	1,769
Coralline Oolite -	Oolitic lin[illegible] - -	17 -	1,786
? ? -	Shales, sa[illegible]s, and limestone	117 -	1,903
		1,906	—

There is still some uncertainty as to the relations of the lowest strata; they may belong to the Oxford Clay, or they may represent the lower Coralline series of Dorsetshire. This point will be cleared up as the boring progresses. The greater part of the Kimeridge Clay is very fossiliferous, some of the fossils being new to England; the least productive parts are the highly calcareous shales or cement stones; some of the limestones are mainly composed of small oysters; an example is shown in the small core at the side of the case.

The smaller diagram gives a section of the Cretaceous and Oolitic rocks of the south-east of England; distinguishing those previously known in that area from those discovered by the boring. The same point is brought out in the horizontal section, which also serves to illustrate the structure of the Wealden area. A simple inspection of these diagrams will show the amount of information already obtained by the boring. If the Palæozoic rocks should not be reached, the boring will still have yielded most valuable results, for we shall have acquired a knowledge of the Oolitic strata of this area, such as could not possibly have been obtained in any other way.

Some valuable beds of Gypsum were discovered in the Purbeck Beds; these are now being worked, giving rise to a new branch of industry in Sussex.

The position of the boring is shown in the Geological Model of the Weald which is exhibited in an adjoining case. Further details of the structure of the districts can be seen in the maps and sections of the Geological Survey.

3271. Geological Maps in relief, embossed in paper, of ENGLAND AND WALES, after Sir R. I. Murchison, and THE ISLE OF WIGHT, after H. W. Bristow, F.R.S. *Henry F. Brion.*

3272. Model of Etna. *Th. Dickert, Poppelsdorf, near Bonn.*

The model exhibited is a scientific work, much valued and used by all the larger institutes of Germany for illustration in their science classes.

3273. The Great Crater of Vesuvius. Photograph, showing the interior after the eruption of April 1872.

Robert James Mann, M.D.

This photograph was taken by Mr. J. M. Black from the gap in the broken edge of the rim. The top of the great rent, extending north and south through one side of the cone into the Atreo del Cavallo, is shown on the further side of the crater between the rounded and pointed eminences.

3274. Four Sketches representing a **Volcanic Eruption,** to illustrate the form.

Mineralogical and Geological Cabinet of the School of Industry, Cassel (Dr. H. Möhl).

3275. Four Views of Crater Eruptions.

Mineralogical and Geological Cabinet of the School of Industry, Cassel (Dr. H. Möhl).

The drawings are used as wall maps to illustrate geological lectures. For more information, v. Papers XI., XIII.

3276. Photographic Views (2) of Mount Sorrel granite quarries, Charnwood Forest, Leicestershire, by Messrs. T. and J. Spencer. *W. J. Harrison, Town Museum, Leicester.*

This rock is a tough hornblendic granite, largely used for revatt setts, kerbs, &c.

3277. Photographs of the slates and syenites of Charnwood Forest, and of a column of the hard rocks of Leicestershire erected in the grounds of the Leicester Town Museum.

W. J. Harrison, Town Museum, Leicester.

These rocks are coloured as Cambrian on the maps of the Geological Survey, but they have yielded no fossils, and the evidence of superposition is not clear, as the oldest rocks near are of Mountain Limestone. The views are by Messrs. J. Burton and Sons.

3278. Rock Sections. Series prepared for microscopical examination. *James How & Co.*

3281. Relief Map of the Habichtswald, near Cassel, province Hesse-Nassau; petrographically coloured.

Friedrich Sievers, Wehlheiden, near Cassel.

Constructed from the maps of the former electorate of Hesse, the level lines in which were taken at a distance of 60 Prussian feet apart, so that the surface of the North Sea is represented by 0.

The distribution of the rocks is shown in colours according to the observations of Dr. Möhl and the exhibitor, as follows:—

Carmine - - -	- the lower group of the "Bunter" sandstone.
Reddish yellow -	- the upper group of the same.
Blue - -	- "Muschelkalk."
Light-greenish grey	- clay and sand with lignite.
Dark-greenish grey	- marine sand rich in fossils, and septarium clay (Upper Oligocene).
White - -	- alluvium.
Black - -	- basalt.
Brown - -	- basalt conglomerate.

Villages are shown in vermilion, railways and high roads in black, standing and running waters in blue, with corresponding figures referring to index, which is attached to the relief.

3282. Model of the Altendorf Trough, "Flötz Sonnenschein." *"Berggewerkschaftskasse," Bochum, Westphalia.*

3283. Fourteen Models of Faults in the Carboniferous rocks. *"Berggewerkschaftskasse," Bochum, Westphalia.*

3285. Geological Sections. *University Museum, Oxford.*

Coast of Dorset, from Lyme Regis to Isle of Portland.
Slapton Sands, between Dartmouth and Plymouth.
Dunolly Castle, near Oban.
Brent Tor, near Tavistock.
View from Exmouth.
Parallel Roads of Glen Roy.
Section from Beerhead to Axmouth.
Country between Malverns and Cotswolds.
Coast of Dorset between Charmouth and Abbotsbury.
Submarine Forest of Stolford.
Views of the Coast of Devon E. and W. of Sidmouth (2).
Sections of Landslip
Bird's Eye View of part of Devonshire.
View of Cliffs, Lyme Regis.

3287a. Microscopical Preparations of Spanish Rocks. *Francisco Quiroga, Madrid.*

1. Spanish silicious diatoms
2. Rutile from Horcaguelo (Madrid).
3. Molibdate of lead from Quentar (Granada).
4. Tourmaline from Buitrago (Madrid).
5. Tremolite from the province of Guadalayera, composed of tremolite and glass.
6. Meteorolite from Molina (Murcia), 24th December 1858; composed of pyroxene, peridot, and other metallic substances.
7. Meteorolite from Molina (Murcia), 24th December 1858; insoluble silicate produced by the action of acids; formed of pyroxene.
8. Meteorolite from Cangas de Onis (Asturias), 6th December 1866; it is formed of pyroxene, peridot, and metallic substances.
9. Dunyte from the Serrania de Ronda, formed of peridot picotite.*
10. Dunyte from the Serrania de Ronda, formed of peridot, picotite.*
11. Chrysolite from the Serrania de Ronda, formed of peridot, diopside.*
12. Serpentine from Sierra Parda (Serrania de Ronda), formed of peridot, serpentine, hematite.*
13. Serpentine from Sierra Parda (Serrania de Ronda), formed of serpentine, peridot, magnetite, hematite.*
14. Serpentine from Istau (Serrania de Ronda), formed of serpentine and magnetite
15. Serpentine from Ystau (Serrania de Ronda), formed of serpentine and magnetite.

---

* Brevis apuntis auria del origen peridotico de la serpentina de la Serrania de Ronda. by Don T Macpherson. Anales de la Sociedad Española de Historia Natural, J. iv.

16, 17. Serpentine from Real del Dugue (Serrania de Ronda), formed of serpentine and magnetite.
18. Serpentine from Ronda, formed of serpentine and magnetite.
19. Serpentine from Torrevieja (Alicante), formed of serpentine and magnetite.
20–22. Serpentine from Barranco de San Juan (Granada), formed of serpentine and magnetite.
23. Serpentine from the Sierra of Guejar (Granada), formed of serpentine and magnetite.
24. Chlorite state of Cogulludo, formed of chlorite and magnetite.
25. Anthrakonite from Galicia, formed of fetid calcite.
26. Nummulitic limestone from San Vicento de la Barguera (Santander).
27. Cipolin from Robledo de Chavela (Madrid), formed of calcite and muscovite.
28. Chloritic limestone from Almaden, formed of calcite chlorite.
29. Obdurate clay of Segovia (cretaceous period), formed of clay, quartz.*
30. Clay slate of Peña de Penilla (silurian age), Segovia, formed of clay, feldspar, and quartz.
31. Talcose slate of the Escorial, formed of talc, quartz, and muscovite.
32. Felsyte from the Barranco del Cebollon, Granada, formed of felsyte, quartz, amphibole.
33, 34. Felsyte from the Escorial, formed of felsyte alone.
35. Felsyte from Peguerinos (Avila) formed of felsyte, quartz.†
36. Granite from Robledo de Chavila (Madrid), formed of orthoclase, quartz, muscovite, and hornblende.
37. Gneiss from Chapas de Marbella (Serrania de Ronda), formed of orthoclase, quartz, muscovite, apatite.‡
38. Gneiss from Mijas (Serrania de Ronda), formed of orthoclase, quartz, and muscovite.
39. Garnetiferous gneiss from Huertal (Granada), formed of orthoclase, quartz, muscovite, garnet, and picotite.
40. Gneiss from Robledo de Chavila (Madrid), formed of orthoclase, quartz, muscovite, and hornblende.
41. Gneiss from the Escorial, formed of muscovite and quartz and orthoclase.
42. Micaceous gneiss from the Escorial, formed of muscovite and quartz.
43. Coccolite with garnetite from the Escorial, formed of diopside and garnet.
44. Coccolite from Riara (Segovia), formed of diopside, garnet, hematite, quartz with fluid cavities, and apatite.§
45. Coccolite from Riarja (Segovia), formed of diopside and hematite.
46. Coccolite with garnetite from Riarja, Segovia, formed of diopside and garnet.
47. Garnetite from Riarja (Segovia), formed of garnet and diopside.
48. Hyalomicte from Riarja (Segovia), formed of quartz and muscovite.
49. Ophite from Puerto Real, Cadiz, formed of plagioclase, augite, diallage, epidote, hornblende, magnetite.‖

---

* Excursion geologica por la provincia de Segovia, por Don Alfonso de Aristo y Sarrinaga y Don Francisco Quiroga y Rodriguer. Anales de la Socd. Espanola de Hist. Natural, J. iii.

† Anales de la Soc. Esp. de Hist. Nat. J. iv. Actas, p. 73, sesion del 1 de Setz. de 1875. Paper read by F. Quiroga.

‡ See (*), p. , and Memoria 10bre la estructura de la Serrania de Ronda, by T. Macpherson. Cadiz, 1874.

§ Observaciones sobre algunas rocas de Riarja (Segovia), by Quiroga. An. de la Soc. Esp. de Hist. Natural, J. v.

‖ Bosquijo geologico de la provincia de Cadiz, por T. Macpherson. Cadiz, 1872, and An. de la Soc. Esp. de Hist. Nat. J. v.

50. Ophite from Puerto Real (Cadiz) formed of felspar, hornblende, magnetite.
51. Diabase from the Sierra de Cordova, formed of plagioclase, chlorite, augite, magnetite.
52. Garnetiferous amphibolite from Pedraya de la Sierra (Segovia), formed of amphibole and garnet.
53. Garnetiferous amphibolite from Pedraya de la Sierra, composed of amphibole and quartz with fluid cavities.
54. Quartziferous amphibolite from the escorial, formed of amphibole and quartz.
55. Quartziferous amphibolite from Dilar (Granada), formed of amphibole and quartz.
56. Garnetic quartziferous amphibolite from Toril de Dilay (Granada), formed of amphibole, quartz, garnet, and picotite.
57. Quartziferous amphibolite from Laguna de Bacares (Granada), formed of amphibole, quartz, and picotite.
58. Quartziferous amphibolite from Barranco de los Araligos (Granada), formed of hornblende and quartz.
59. Quartziferous amphibolite from Barranco de los Araligos (Granada), formed of hornblende and quartz.
60. Quartziferous amphibolite from Barranco de los Araligos (Granada), formed of hornblende, quartz, garnet, and hematite.
61. Quartzdiorite from Almaden, formed of plagioclase, hornblende, magnetite, quartz, with apatite.
62. Quartzdiorite from Almaden, insoluble from the action of acids.
63. Diorite from Peguerinos (Avila), formed of plagioclase, hornblende.*
64. Idem from Peguerinos (Avila), formed of plagioclase, hornblende.
65. Idem from Peguerinos (Avila), formed of plagioclase, hornblende, magnetite, augite
66. Idem from Peguerinos (Avila), formed of plagioclase, hornblende, magnetite, viridite, calcite, and quartz.
67. Diorite from Peguerinos (Avila), formed of plagioclase, hornblende, magnetite, viridite, and augite
68. Trachyte from Cartagena, formed of sanidin, hornblende, magnetite.
69. Trachyte from Telde (Grau Canaria), formed of sanidin, magnetite.
70. Trachyte from Guia (Grau Canaria), vide No 8 of the collection of Grau Canaria Rocks, by M. S. Calderon, formed of sanidin, magnetite, hornblende †
71. Trachyte from Palmas (Grau Canaria), vide No. 5 of the collection of Grau Canaria rocks of M. S. Calderon, formed of sanidin, magnetite
70. Trachyte from Grau Canaria, vide No. 7 of collection of Grau Canaria rocks of M. S. Calderon, formed of sanidin, magnetite, augite, hornblende
73. Trachyte from Grau Canaria (No. 9 of collections of Grau Canaria rocks, by M. S. Calderon, formed of sanidin, magnetite, hornblende
74. Trachyte from La Cumbro (Grau Canaria), No. 3 of the collection of Grau Canaria, by M. S. Calderon, formed of sanidin, magnetite, augite, aragonite.
75. Tufa from Artenaza (Grau Canaria), No. 53 of the collection of Grau Canaria of M. S. Calderon, formed of sanidin, clay.

* Anales de la Soc. Esp. de Hist. Nat. J. iv. Actas, p. 73, sesion del 1 de Setz. de 1875. Paper read by F. Quiroga.

† Resena de las rocas de la Isla Volcanica Grau Canaria, por Salvador Calderon. An. Soc. Esp. de Hist. Natural, J. iv.

76. Plagioclase dolerite from Salto del Castellano (Grau Canaria) No. 45 of the collection of Grau Canaria rocks, by M. S. Calderon, formed of plagioclase, augite, and magnetite.
77. Basalt from Las Palmas, Grau Canaria, No. 40 of collection of Grau Canaria rocks of M. S. Calderon, formed of augite, magnetite, olivine, plagioclase.
78. Basalt from Las Palmas, Grau Canaria, No. 39 collection Grau Canaria rocks of M. S. Calderon, formed of augite, magnetite, olivine, plagioclase.
79. Plagioclasbasalt from La Cumbre (Grau Canaria), vide No. 53 of collection of Grau Canaria rocks of M. S. Calderon, formed of plagioclase, augite, magnetite, hematite.
80. Nephelinebasalt, from La Cumbre (Grau Canaria), No. 36 of the collection of Grau Canaria of M. S. Calderon), formed of nepheline, augite, magnetite, plagioclase, hematite.
81. Rosed felsyte from the Escorial, formed of felsyte and hornblende.
82. Serpentine from Burgos, formed of serpentine, diallage, magnetite.
83. Phonolyte from Agacte, Grau Canaria (No. 23 of collection of Grau Canaria rocks of M. S. Calderon), formed of sanidin, nepheline, hornblende, sphene.
84. Leptynyte from Sierra de Guadarrama, formed of orthoclase, quartz, muscovite, apatite.
85. Diorite from Peguerinos (Avila), formed of plagioclase, hornblende, magnetite, augite.
86. Diorite from Buitrago (Madrid), formed of plagioclase, hornblende, magnetite.
87. Ophite from Pando (Santander), formed of plagioclase, augite, diallage, hornblende, viridite epidote, magnetite.*
88. Ophite from Pando (Santander), treated by acids, formed of plagioclase, augite, diallage, epidote.
89. Altered ophite from Pando (Santander), formed of plagioclase, augite, diallage, magnetite, and viritite.
90. Garnet fils of Riaza (Segovia), formed of garnet, hornblende, plagioclase.†

3288. Geological Sections of five proposed lines of railway through the counties of Surrey and Sussex, from Brighton to London, made and surveyed in 1837, by Joseph Gibbs, C.E., and Arthur Dean, C.E. *Free Library and Museum, Brighton.*

South-Eastern, Brighton line, from Carlton Hill, Brighton, to junction with the Greenwich Railway. Direct line, from Church Street, Brighton, to junction with the Greenwich Railway. Gibbs' line, from Western Road, Brighton, to junction with the Croydon Railway. Stephenson's line, from North Lane, Brighton, to Nine Elms. Line without a tunnel, from Brighton to Kennington Oval.

3289. Sections showing the positions of the **Palæozoic Rocks** beneath the Tertiary or Secondary Strata, with some specimens of the former. *Professor Prestwich, Oxford.*

1. Section of the Kentish Town Well.
2. Specimens of some of the strata passed through in the above well.
3. Section of the Artesian Well boring at Ostend.

---

* Opita de Pando (Santaudar), por F. Quirago au de la Soc. Esp. de Hist. Nat. J. V.
† Vide Elemente de Pelographic von Du. A. von Lasaulx. Bonn, 1875.

3290. Geological Section from **Paris** to **Brest.**

Delesse, Paris.

This outline section has been executed, under the direction of M Mille, Chief Engineer of Roads and Bridges, by Messrs. Torger, Delesse, and Guillier. It is on a scale of 40,000 for the length, and 20 times larger for the heights. It follows the line of the railway which, leaving Paris, passes by Bonneval, Chateaudun, Vendome, Tours, Angers, Nantes, Vannes, and Quimper, and comes out at Brest. Many classic regions are traversed in this itinerary, as the Paris basin, Beauce, Touraine, the Valley of the Loire, and a part of Brittany

On this section can be followed the su ession of the different geological stages, which are marked the whole of the railway; their position is determined by their height above the f the sea, so that, notwithstanding the exaggeration of the scale of eleve t is easy to ascertain their relative position.

In the regions of La Beauce the subterr ean sources of water supply have been specially studied.

This section also affords information as to the materials of construction furnished by each geological stage, and the vegetable soil and the nature of the crops.

Geological studies of this kind are eminently useful if they precede the formation of railways, because they supply a knowledge of the difficulties likely to be encountered during the course of construction, as well as the resources which may be reckoned on in each region traversed, and even when made after the completion of a railway, they supply facts highly useful to science and industry.

In pursuance of the orders of M. de Franqueville, Director-General of Bridges and Railways, these geological surveys have been carried on by M. Mille over a great part of France.

3291. Original Sketches, illustrative of **Geological Scenery** and sections, taken by Dr. Buckland between 1815 and 1840. *The Oxford University Museum, Geological Section.*

1. Landslip, Lyme Regis.
2. View of Coast near Lyme Regis.
3. View of Coast near Sidmouth.
4. View of Coast near Sidmouth.
5. Submarine Forest of Stolford near Bridgewater.
6. View of Coast between Charmouth and Abbotsbury.
7. Bird's eye view of Dartmoor and south coast of Devon.
8. View of Vale of Severn between Malverns and the Cotswolds.
9. Coast view between Beerhead and Axmouth.
10. Parallel roads of Glen Roy.
11. View of Exmouth.
12. Brent Tor near Tavistock.
13. Dunolly Castle near Oban.
14. View of Shapton Sands.
15. View of south coast of Lyme Regis with Portland in the distance.

3292. Geology. Collection of specimens of felspars and amphibolitic rocks from Belgium and the French Ardennes. This

collection comprises about 20 specimens, average dimensions 10 centimètres by 15.

Six chromolithographs of drawings of minerals and rocks as seen through the microscope. *A. Renard, Louvain.*

3293. Specimens illustrating the production by **Compression** of **Natural** and **Artificial Slaty Cleavage.** *H. C. Sorby.*

Specimens of slate rocks, showing, by various facts, that they have been greatly compressed in a line perpendicular to the cleavage.

Pipe-clay mixed with portions of blue paper, and also with iron scales, being the results of the first experiments made to show that a structure like that which causes the cleavage in slates can be artificially produced by pressure.

Artificial cleavage in compressed flaky graphite, being as perfect as that in any slate rock.

3294. Specimens illustrating the **Metamorphic Origin of Mica Schist,** and the difference between stratification, foliation, and cleavage foliation. *H. C. Sorby.*

"Ripple drift" in slate rocks in which the cleavage cuts the stratification at a considerable angle.

"Ripple drift" in contorted and highly metamorphosed mica schist, thus proving the original stratified nature of the rock.

Mica schist with foliation in the plane of stratification, being rock metamorphosed before being compressed.

Mica schist with foliation in the plane of cleavage, developed by compression, before the work was metamorphosed.

3295. Microscopical Photographs of sections of iron and steel. *H. C. Sorby.*

The above were photographed by means of strong surface illumination, showing structures due to the arrangement of crystals of iron combined with a varying amount of carbon, of portions of slag, and of crystalline plates of graphite. Note the contrast between the structure of cast iron, cast steel, and meteoric iron, although all have solidified from fusion.

3296. Microscopical Sections of iron and steel. *H. C. Sorby.*

The above were prepared by very carefully grinding down and polishing the surface so as to avoid all such burnishing action as would alter the form or structure of the ultimate crystalline particles. The whole section is then placed in very dilute nitric acid, and carefully examined in water under the microscope, time after time, until the irregular action of the acid on the different constituents has advanced so far as to show the general structure to the greatest advantage. The surface is then well washed, dried, and gently wiped, and finally protected by a thin glass cover cemented down by Canada balsam.

3297. Working Model illustrating the **Formation** of **"False Bedding"** in **Stratified Rocks.** *H. C. Sorby.*

The drifting action of the current of water is represented by the screw, which carries forward the sand until it falls down and accumulates on the slope at the angle of rest. The larger fragments roll to the bottom, and the

3301. Collections of Rock Specimens.
Bernhard Stürtz, Bonn.

3302. Collection of Fossils. *Bernhard Stürtz, Bonn.*

3303. Collection of Specimens of Lodes.
Bernhard Stürtz, Bonn.

3304. Slabs with Fossils. *Bernhard Stürtz, Bonn.*

3305. Glass Model of the barren part of the "Flötz" of the coal basin of the Wurm Mining district, Aix-la-Chapelle.
United Coal Mining Co., Aix-la-Chapelle (Director Hilt).

3306. Transverse Section through the barren "Flötz" of the coal basin of the Wurm.
United Coal Mining Co., Aix-la-Chapelle (Director Hilt).

3307. Sections of Typical Rocks (30 specimens), a selection of Prof. J. Roth, Berlin; with a commentary by Prof. H. Rosenbusch, Strasburg. *R. Fuess, Berlin.*

3308. Sections of Typical Rocks (30 specimens), with a commentary; a selection by Prof. F. Zirkel, Leipsic.
R. Fuess, Berlin.

3309. Sections of Typical Basalts (30 specimens), a selection by Prof. H. Möhl, Cassel; with a commentary.
R. Fuess, Berlin.

3310. Sections of Rock-forming Minerals (30 specimens), a selection by Prof. H. Rosenbusch, Strasburg; with a commentary. *R. Fuess, Berlin.*

3311. Sections of the Rocks of the Kaiserstuhl (30 specimens), a selection by Prof. H. Rosenbusch, Strasburg.
R. Fuess, Berlin.

3312. Sections of the Eruptive Rocks of Hungary and Servia (30 specimens), a selection by Prof. Szabo, Budapest; with a commentary. *R. Fuess, Berlin.*

3313. Sections of Typical Rocks (30 specimens), a selection by Prof. F. Zirkel, Leipsic; with a commentary.
R. Fuess, Berlin.

3314. Sections of the most Characteristic Rocks of the Huronian iron region, Lake Superior, U.S.A. (30 specimens), a selection by Major T. B. Brooks, Wisconsin Geological Survey, and microscopically examined by Dr. Wichmann, Leipsic.
R. Fuess, Berlin

3321. Thin Sections of typical rocks in a box (90 specimens). *Voigt and Hochgesang, Göttingen (Gust. Voigt).*

Contains rocks selected according to F. Zirkel's "Microscopical Characters of Minerals and Rocks."

3322. Thin Sections of typical rocks in a box (20 specimens). *Voigt and Hochgesang, Göttingen (Gust. Voigt).*

Collected by Dr. v. Seebach, and described by Dr. F. Zirkel, Leipzic.

3323. Series of the most characteristic Porphyries of Silesia, with thin sections of the same, in a case. *University of Breslau (Prof. A. von Lasaulx).*

3324. Collection of Thin Sections of the rocks of Saxony. *Royal Saxon Mining Academy, Freiberg.*

3325. Series of Leaf Remains, from the Lower Bagshot beds (Middle Eocene), collected on the coast between Poole Harbour and Bournemouth. *J. Starkie Gardner.*

These leaves occur in isolated lenticular patches, usually of small extent, and were deposited in fresh water, which probably flowed from the north-west. Their horizon is slightly higher than the well-known leaf beds of Alum Bay, the flora of which presents considerable differences in character. Collections from Alum Bay are in the British and Jermyn Street Museums.

3326. Globe mounted for the study and demonstration of the angular relations of directions presented by lodes, dykes, lines of dislocation, mountain chains, coast lines, and river valleys. *Jos. P. O'Reilly, Dublin.*

This globe allows of the tracing of great circles through given points, with great facility and rapidity. These great circles can be transferred to maps, and serve as bases of comparison for the lode systems of mining districts, and in general for all geological lines of direction.

The above was designed by the exhibitor in 1874, and used for public lectures. A similarly mounted globe was shown in Paris at the Geographical Exhibition of 1875, by M. Chancourtois.

3327. Portable Apparatus, for preparing Sections of rocks, minerals, fossils, &c., for microscopic examination. *F. C. Cuttell.*

3328. Lapidary Apparatus for slitting, grinding, and polishing rocks, pebbles, fossils, &c., especially adapted for the preparation of thin sections of rock or other hard material for microscopical examination. Designed by Mr. James B. Jordan, and manufactured by Messrs. Cotton & Johnson, Soho. *James B. Jordan.*

The district of JENA, on the SAALE; 12 sections.
The district of RIECHELSDORF; 6 sections.
The district of HALLE; 4 sections.
The COAL BASIN of SAARBRÜCK; 13 sections.
TOPOGRAPHICAL BASIS to a part of the above-named sections, representing the OUTCROP of the FLÖTZE; 6 sections.
The same sheets representing the FLÖTZE in PROJECTION; 6 sections.
The COAL MOUNTAIN (CARBONIFEROUS) and PERMIAN formation of the vicinity of HALLE, with the diluvium removed; 4 sections.
The same in PROFILE.
GEOLOGICAL AGRICULTURAL MAP of a part of the environs of BERLIN.
A MAP, containing eight parts of the SPECIAL GEOLOGICAL MAP OF PRUSSIA.
SEVEN SMALLER MAPS containing the explanations to the above.

Royal Geological Institution and Mining Academy of Berlin (Prof. Hauchecorne, Director).

3332. Geognostical and Agricultural Map of the manor of Friedrichsfeld, near Berlin, an example of a new cartographic method.

1. Map, scale $\frac{1}{5000}$
2. Map, scale $\frac{1}{25000}$
3. Length profile, scale $\frac{1}{10000}$
4. Map of ground rent, scale $\frac{1}{10000}$
5. Die geognostische und agronomische Kartographie, Text, Berlin, Ernst and Korn, 1875.

Prof. Dr. Orth, Berlin.

3333. Six large "Petrological" Plans.

I. & II. Profiles of soils which filter water.
III. & IV. Profiles of soils which do not filter water.
V. & VI. Profiles of rich soil suitable for the cultivation of the sugar beet.
VII. Text, Berlin, Wiegand, Hempel, and Parey, 1876.
Explanation to the above. *Prof. Dr. Orth, Berlin.*

The learned English physician, Dr. Lister, in the year 1683, proposed to the Royal Society of London, to prepare a map which should represent English soils and minerals, their distribution to be shown by special colours, &c. The above maps represent a new mode of geological "chartography," and exhibit the soil in its geographical position, and with its economical uses in a more precise manner than has hitherto been possible.

3334. Plan of the Royal Heinitz-Dechen Coal Mine, consisting of—

a. Plan of the whole mine (6 plates).
b. 25 special ground plans (23 plates).
c. A profile plan (10 plates).

Royal Mining Directory, Saarbrück.

3335. Transverse Section through the **Heinitz** and **Reden** mines, respectively through the "Fat Coal" and the "Flame Coal" part of the Saarbrück Coal Basin (8 plates).
Royal Mining Directory, Saarbrück.

3336. Special Geognostical Maps (2 plates), section Reden and section Dudweiler. *Royal Mining Directory, Saarbrück.*

3337. Sheets to illustrate **Position and Mining Drawing** in the Saarbrück district (3 sheets with cover).
Royal Mining Directory, Saarbrück.

3338. Explanation of the Exhibited Objects.
Royal Mining Directory, Saarbrück.

3339. Geognostic Maps of the Bavarian Alps in a single plate. *Geognostic Survey of Bavaria (Dr. Gümbel).*

3340. Geognostic Map of the Boundary Mountains, Eastern Bavaria, Sheet I.
" " " II.
" " " III.
" " " IV.
" " " V.
Geognostic Survey of Bavaria (Dr. Gümbel).

3341. Geognostic Sheet. Views of the Bavarian Alps.
" Fichtelgebirge I.
" Views from the eastern Bavaria boundary mountains.
" Fichtelgebirge II. (in progress).
" Views of the Fichtelgebirge.
Geognostic Survey of Bavaria (Dr. Gümbel).

3342. Four Single Sheets of the Original Geognostic Survey, showing the different stages of progress, scale $\frac{1}{5000}$.
Geognostic Survey of Bavaria (Dr. Gümbel).

3343. Geognostic Detail Sheet reduced from the single sheets, scale $\frac{1}{25000}$.
Geognostic Survey of Bavaria (Dr. Gümbel).

3344. Geognostic Sheet of a part of the Upper Bavarian Lower Miocene (Oligocene) beds.
Geognostic Survey of Bavaria (Dr. Gümbel).

These maps, while exhibiting the geognostic work done in Bavaria, also illustrate the mode in which the maps published on the scale of 1:100,000 have been produced. The land tax maps scale 1·5,000 have been used for this purpose, and the observations made were entered on the spot (sheets 13–15), and afterwards geognostically coloured. These observations have been then transferred to maps of a different scale 1.25,000 (Sheet No. 16), then to the military atlas 1.50,000 (No. 18), and lastly to the scale of those published 1:100,000 (1-11). Each original sheet may be obtained for the actual cost of production.

3345. Muthung's Survey Map of the mountain district of Upper Silesia, original drawing, scale $\frac{1}{8000}$ in nine special sections, from *a* to *i* of the chief section, No. 6, together with two net maps for the north-eastern and south-western part of the drawing lithographed on scale of $\frac{1}{100000}$.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau).

This map, executed in the proportion of 1:8,000, is based upon a special triangulation by Prof. Sadebeck, and Messrs. Sartor and Hörold, in which are inserted reduced copies of the official survey maps and other special plans of mines, railways, towns, &c. The rectangular net of the map is determined by parallels to the meridian of the chief triangular point of the Trockenberg near Tarnowitz.

3346. Photographic reduction of the nine sections on a scale of $\frac{1}{25000}$, not retouched; carried out by Ed. v. Delden, Breslau, viz.,

a. Nine unmounted small sheets bound in card.

b. Mounted, like chief section No. 6 of the map drawing.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau).

a. shows the photographic reduction of the nine original sections above mentioned, as prepared by Ed. v. Delden of Breslau. On plate *b.* these nine small sheets appear mounted and united to a chief section of the net of the survey map. The maps 4–6 show the use of the photographic map on the scale of 1:25,000 as a topographical basis for various mining and other industrial purposes. The map shows the important mining districts of the towns Beuthen, Königshütte, and Kattowitz, being the first sheet of a new map of Upper Silesia, which was not only destined to exhibit the coal beds, but also the important deposits of zinc and lead ores of the Muschelkalk basin.

A special wall map is exhibited in which the mineral boundaries are shown in different colours, but as in those before mentioned faint black lines are used to show positions of places and boundaries of districts and mining rights. The map illustrating the water-supply project represents a larger district on the same topographical basis, and shows the relation intended to be observed between the supply and the consumption.

3347. Principal Section, No. 6, of a map of a coal deposit and ore deposit in Upper Silesia, scale $\frac{1}{25000}$. To complete and elucidate this, Hörold's map of the ore deposits of the Polish Upper Silesian Muschelkalk is added, scale $\frac{1}{50000}$, together with a number of mountain profiles from Dr. Ferd. Römer's Geology of Upper Silesia.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau).

3348. Muthung's Survey Map of the mountain district of Beuthen, with coloured boundaries of the mining fields and districts, scale $\frac{1}{25000}$.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau)

3349. Survey Map of the preliminary works for the projected water supply of the industrial districts of Upper Silesia, scale $\frac{1}{8000}$, autographically printed on stone (M. Spiegel, Breslau).

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau).

Example of a special map for industrial use for marking projected railroads, waterways, &c. A reprint from the original survey map scale 1:8,000.

3350. Map of the Industrial District of Upper Silesia, scale 1: 8,000: authographic lithography.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (M. Spiegel, Breslau).

3351. Attempt towards a Petrographic and "Flötz" Map of the Waldenburg mountain district, drawn by the mining surveyor, Lange, in the year 1807.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau).

This map is of historical interest, as the first attempt to form a geological map representing the relations between important mining bands in the Waldenburg coal district. The scientific and technical observations appear, even at the present time, to be quite correct.

3352. "Flötz" Map of the Coal Fields at Kohlau (now the Consolidated Abendröthe Mine), drawn by the mining surveyor, Schultze, in the year 1804.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau).

A map some years older than the preceding.

3353. Five Interesting Sections of large **Basalt Quarries.**

Mineralogical and Geological Cabinet of the School of Industry, Cassel (Dr. H. Möhl).

3a. Ceteosaurus Oxoniensis.

Left femur.
Dorsal vertebra, 2 views.
Left humerus.
Ilium, 2 views.

Megalosaurus Bucklandi.

Upper jaw.
Lower jaw.
Scapula.
Pubis.
Right tibia.
Ilium.
Caracoid.
Rib.
Ischium, 2 views.
Sacrum.

Dr. Acland, F.R.S., on behalf of the Radcliffe Trustees.

3354. Plates of British Fossils, from the annual volumes of the Palæontographical Society.

The Rev. Thomas Wiltshire, M.A., Sec. G. S.

Illustrating :—

Pleistocene Mammalia (skull of Felis spelæa).
Upper Greensand Urchins (Caratomus rostratus).
Lower Greensand Urchins (Trematopygus faringdonensis).
Wealden Reptilia (Radius and Ulna of Iguanodon Mantelli).
Purbeck Mammalia (Teeth and Jaws of Stylodon, Leptocladus, Belodon, &c.).
Oxford Clay Belemnites (Belemnites Puzosianus; B. porrectus).
Inferior Oolite Corals (Thecosmilia Wrighti; T. Flemingi).
" " Trigoniæ (Trigonia signata; T. Moretoni).
Liassic Corals (Astrocœnia gibbosa, Helistræa Moorei, &c.).
" Starfish (Ophioderma Gaveyi; O. Egertoni).
Carboniferous Flora (Halonia regularis).
Devonian Crustacea (Sylonurus Powriei; Cheirurus articulatus).
" Brachiopoda (Spirifera disjuncta, Spiriferina cristata).
" Fish (Cephalaspis Lyelli; C. Murchisonii).
Silurian Trilobites (Phacops, Amphion, Asaphus).
" Eurypterida (Slimonia acuminata, Plerygotus bilobus).

3355. Collection of Fossil Plants, proving the existence of the elements of recent flora in that of the Tertiary period, comprising examples of the elementary forms of salt and fresh water flora, and of the various continents, including Australia.

Fossil plants from various localities in the Tertiary formation are also exhibited, exemplifying the origin of our recent local flora from ancient types.

This is shown by coloured tickets attached to the specimens.

The change of the fossil *Castanea atavia* into the recent *Castanea vesca* is also illustrated.

Professor Dr. Constantin Baron von Ettingshausen, Graz.

The above are original specimens collected in Styria, Carniola, Croatia, Dalmatia, the Tyrol, Hungary, and Bohemia.

The recent plants bearing closest analogy to the fossil plants are shown for comparison.

In the ancient Tertiary strata the *Castanea atavia* has distantly toothed, or nearly toothless leaves, devoid of thorny points. From the primary vein spring, at a distance from one another, curved secondary veins.

In the Middle Tertiary strata are found leaves of the *Castanea atavia* closely approaching the *Castanea vesca* by approximate secondary veins, and by more numerous and protruding teeth, which, however, are still without thorny points.

In still more recent strata of the Tertiary formation there are found here and there thorny points on the teeth.

In the latest Tertiary strata the leaves of the fossil species are nearly identical with those of the *Castanea vesca*. The secondary veins are more approximate and almost rectilinear, while the teeth are set with thorns.

In all strata where leaves of the *Castanea atavia* have been found, have also been collected the male catkins of that species, which differ from those of the *Castanea vesca* by having somewhat smaller flowers. Examples of these are also added to the collection.

3356. Eocene Fossils. Typical collection, comprising 100 species. *R. Damon.*

3357. Rocks, sedimentary, volcanic, and plutonic. Typical collection, comprising 100 specimens. *R. Damon.*

3357a. Table of British Strata, showing the order of their superposition, and the relative thickness of the formation.

William Bristow, F.R.S., F.G.S., Director of the Geological Survey of England and Wales.

In the construction of this table, the object has been to produce a cheap diagram for educational purposes, and for illustrating lectures on geology.

When thus used, the four columns into which the table is divided may be printed in separate slips, and then coloured and mounted side by side. Each slip being complete in itself, any one, two, or more may be employed to suit the special purposes for which they are required. Thus, for elementary classes the first three columns may be all that are needed, while for more advanced classes, and in systematic lectures on geology, all may be made use of.

The mode here adopted of showing the grouping and order of succession of the various geological formations in parallel columns in juxtaposition with each other, places the facts before the eye in the most striking and comprehensive way. It has also the recommendation of cheapness, an important consideration in the case of schools.

For reference in the study as well as *on an enlarged scale* as a diagram, the table is susceptible of extension, as additional parallel columns may be filled up with (*a*), the names of the fossils most common in the several formations in different districts; (*b*), the lithological and local characters of the various strata; (*c*), the minerals usually found in or associated with them; (*d*), the useful purposes to which the strata and the mineral substances they contain are applied in the arts, manufactures, &c.; and (*e*), the prevailing agricultural characters and peculiarities of the different formations.

3358. British Rocks. A typical collection of aqueous, metamorphic, plutonic, and igneous rocks. *J. R. Gregory.*

3359. Collection of Fossils.

Dr. Acland, F.R.S., on behalf of the Radcliffe Trustees.

3360. British Typical Fossils. An elementary collection arranged stratigraphically. *J. R. Gregory.*

3361. Diagrams for Lecture Purposes, Two. The drawings enlarged from Davidson's Monograph of the British Fossil Brachiopoda.

George Sharman, Museum of Practical Geology.

Illustrations of characteristic British Carboniferous Brachiopoda.
Illustrations of characteristic British Brachiopoda, from various formations.

3361a. Collection of Fossils most characteristic of the different formations in Russia. 214 specimens.

Mining School in St. Petersburg.

1. Eurypterus Fischeri, Eichw. -	Upper Silurian.	Rotzeküll, Oesel.
2. Asaphus expansus, Lin. -	Lower Silurian.	Duboviki, St. Petersburg.
3. Illænus crassicauda, Schlth. -	„	Popovka, „
4. Amphion Fischeri, Eichw. -	„	Pulkova, „
5. Lituites convolvens, Schlth. -	„	Reval, Esthonia.
6. Orthoceras vaginatus, Schlth. -	„	„ „
7. „ duplex, Wahlb. -	„	Narva, „
8. Euomphalus qualteriatus, Schlth.	„	Reval, „
9. Spirifer superbus, Eichw. -	Upper Silurian.	Petropavlovsk, Ural.
10. Atrypa prunum, Dalm. -	„	Lode, Esthonia.
11. „ arimaspus, Eichw. -	„	Petropavlovsk, Ural.
12. Rhynchonella Wilsoni, Sow. -	„	Johannis, Esthonia.
13. „ nucella, Dalm. -	Lower Silurian.	Popovka, St. Petersburg.
14. Pentamerus esthonus, Eichw. -	Upper Silurian.	Kattentak, Esthonia.
15. „ borealis, Eichw. -	„	Hapsal, „
16. „ acutolobatus, Sandb.	„	Petropavlovsk, Ural.
17. „ Knightii, Vern. -	„	Petuhovsk, „
18. „ baschkiricus, Vern.	„	Satkinski Pristan, Ural.
19. „ vogulicus, Vern. -	„	Bogoslovsk, Ural.
20. „ „ Vern. -	„	„ „
21. Porambonites æquirostris, Schlth.	Lower Silurian.	Sommerhausen, Esthonia.
22. Porambonites Tscheffkini, Vern.	„	Pulkovo, St. Petersburg.
23. „ reticulatus, Pand.	„	Gostinopolskaia Pristan, Novgorod.
24. Platystrophia lynx, Eichw. -	„	Pulkova, St. Petersburg.
25. Orthis obtusa, Pand. - -	„	Popovka, „
26. „ extensa, Pand. - -	„	„ „
27. „ calligramma, Dalm. -	„	„ „
28. „ parva, Pand. - -	„	Pulkovo, „
29. Orthisina plana, Pand. -	Lower Silurian.	River Ishara, „
30. „ anomala, Schlth. -	„	Reval, Esthonia.
31. „ hemipromites, Buch.	„	Pulkovo, St. Petersburg.
32. „ adscendens, Pand. -	„	Popovka, „
33. „ Verneuilli, Eichw. -	„	Reval, Esthonia.
34. Leptæna Humboldtii, Vern. -	„	Erras, „
35. „ imbrex, Pand. -	„	Teve, „
36. „ transversa, Pand. -	„	Pulkovo, St. Petersburg.
37. „ oblonga, Pand. -	„	„ „
38. „ uralensis, Vern. -	Upper Silurian.	River Tsvestka, Ural.
39. Siphonotreta unguiculata, Eichw.	Lower Silurian.	Popovka, St. Petersburg
40. Siphonotreta verrucosa, Eichw.	„	Pulkovo, „
41. Obolus Apollinis, Eichw. -	„	Narva, Esthonia.
42. Crania antiquissima, Eichw. -	„	Popovka, St. Petersburg.
43. Echino-encrinus angulosus, Pand.	„	„ „

44. Cryptocrinus lævis, Pand. -	Lower Silurian.	Popovka, St. Petersburg.
45. Hemicosmites pyriformis, Buch	"	Pulkovo, "
46. Heliocrinus balticus, Eichw. -	"	Reval, Esthonia.
47. Glyptosphærites Leuchtenbergii, Volb.	"	Popovka, St. Petersburg.
48. Echinosphærites aurantium, Wahlb	"	" "
49. Chætetes petropolitanus, Pand.	"	Pulkovo, "
50. Astylospongia globosa, Eichw.	"	Popovka, "
51. Pseudosiphonia cylindrica, Eichw.	"	" "
52. Pterichthys (Asterolepis) Milleri, Ow.	Devonian -	River Aa, Livonia.
53. Holoptychius nobilissimus, Ag.	" -	River Priksha, Novgorod.
54. Dendrodus biporcatus, Ow. -	" -	River Aa, Livonia.
55. Chelyophorus, sp - -	" -	Orel.
56. Gomphoceras rex, Pacht. -	" -	Zadonsk, Voronejc.
57. Gomphoceras sulcatulum, Vern.	" -	River Sias, St. Petersburg.
58. Arca oreliana, Vern. - -	" -	Orel.
59. Avicula Woerthii, Vern. -	" -	Gostinopolskaia Pristan Novgorod.
60. Spirifer Archiacii, Sow. -	" -	Teletz, Orel.
61. " Anosofii, Vern -	" -	Voroneje
62. " curvatus, Schnur. -	" -	Lechki, Voroneje.
63. " aculeatus, Schnur	" -	Muraievna, Riazan
64. Athyris concentrica, Buch. -	" -	Teletz, Orel.
65 " subpyriformis, Sem. Moll.	" -	Muraievna, Riazan
66 Athyris Puschiana, Sem. Moll.	" -	" "
67. " pectinata, Sem. Moll. -	" -	Ulabie, Tula.
68 Retzia tulensis, Pand -	" -	Malevka, Tula.
69 Atrypa reticularis, Lin -		- Gostinopolskaia Prista. Novgorod.
70 Atrypa reticularis, Lin -	" -	Kadinskaia Pristan, Ura
71. " Duboisii, Vern -	" -	" "
72. " latilinguis, Schnur -	" -	" "
73. Rhynchonella Panderi, Sem Moll	" -	Malevka, Tula.
74. Rhynchonella livonica, Buch -	" -	Zadonsk, Voroneje
75. " Meyendorfii, Vern.	" -	Pskof.
76 Rhynchonella cuboides, Sow. -	" -	Sulem, Ural
77. Orthis striatula, Schlth -	" -	Gostinopolskaia Prista Novgorod
78 Leptæna, Asella - -	" -	Voroneje
79. Chonetes nana, Vern -	"	Malevka, Tula.
80. Stropholosia subaculeata, Murch	" -	Zadonsk, Voroneje
81 Productus Panderi Sem., Moll.	" -	Malevka, Tula.
82 " fallax, Sem., Moll -	" -	"
83 Phillipsia mucronata. M'Coy -	Mountain Limestone.	Borovitshi, Novgorod.

84.	Phillipsia pustulata, Schlth. -	Mountain Limestone.	Tshernishino, Kaluga.
85.	Allorisma regularis, King. -	„	Borovitshi, Novgorod.
86.	Spirifer mosquensis, Fisch. -	„	Verei, Moscow.
87.	„ „ „ -	„	Deviatino, Olonetz.
88.	„ striatus, Mart. -	„	River Indiga, Timan.
89.	„ trigonalis, Mart. -	„	Steshovo, Tver.
90.	Spiriferina Saranæ, Vern. -	„	River Indiga, Timan.
91.	Athyris ambigua, Sow. -	„	Steshovo, Tver.
92.	Camarophoria plicata, Kut. -	„	Taroslavka, Ural.
93.	Streptorhynchus crenistria, Phill.	„	Staritsa, Tver.
94.	Productus scabriculus, Mart. -	„	River Nara, Kaluga.
95.	„ costatus, Sow. -	„	Sloboda, Tula.
96.	„ tubarius, Keys. -	„	Kremenskvie, Kaluga.
97.	„ undatus, Vern. -	„	Tarussa, Kaluga.
98.	„ punctatus, Mart. -	„	Sloboda, Tula.
99.	„ Humboldtii, D'Orb.	„	River Indiga, Timan.
100.	„ cora, D'Orb. -	„	Kassimof, Riazan.
101.	„ longispinus, Flem.	„	Steshovo, Tver.
102.	„ semireticulatus, Mart.	„	Staritsa, Tver.
103.	„ striatus, Fisch. -	„	Borovitshi, Novgorod.
104.	„ giganteus, Mart. -	„	Voronovo, Kaluga.
105.	„ „ -	„	Borovitshi, Novgorod.
106.	„ mammatus, Keys. -	„	River Zilma, Timan.
107.	„ semireticulatus var. Boliviensis, D'Orb.	„	Saraninsk, Ural.
108.	Coscinium cyclops, Keys. -	„	River Indiga, Timan.
109.	Polypora orbicribrata, Keys.	„	„ „
110.	Chaetetes radians, Fisch.	„	River Tagashma, Olonetz.
111.	Syringopora conferta, Keys. -	„	River Sopliussa, Timan.
112.	Lonsdaleia floriformis, Flem.	„	Gurieva, Tula.
113.	Amplexus arietinum, Fisch. -	„	River Kumish, Ural.
114.	Fusulina cylindrica, Fisch. -	„	Zarel Kurgan, Samara.
115.	Clydophorus Pallasi, Vern. -	Permian -	Kazan.
116.	Pecten Kokscharofii, Vern. -	„ -	Kirilof, Novgorod.
117.	Avicula speluncaria, Schlth. -	„ -	Kazan.
118.	Terebratula elongata, Schlth.	„ -	River Dioma, Ural.
119.	Spirifer Schrenkii, Keys. -	„ -	Kirilof, Novgorod.
120.	„ rugulatus, Kut. -	„ -	River Termak, Samara.
121.	Athyris pectinifer, Sow. -	„ -	Kirilof, Novgorod.
122.	„ Royssiana, Keys. -	„ -	„ „
123.	Camarophoria superstes, Vern.	„ -	„ „
124.	Productus hemisphaerium, Kyt.	„ -	River Termak, Samara.
125.	Productus tenuituberculatus, Barbt.	„ -	Kirilof, Novgorod.
126.	Productus Cancrini, Vern. -	„ -	Makarief, Kazan.
127.	Stropholosia horrescens, Vern.	„ -	Kirilof, Novgorod.
128.	Stropholosia Wangenheimii, Vern.	„ -	Grebeni, Orenburg.

129. Avicula Dalailamae, Vern. -	Trias -	Bogdo, Steppe of Kirghises.
130. Ichthyosaurus sp. - -	Jura -	River Volga, Simbirsk.
131. Ammonites Jason, Ziet. -	,, -	Koroshovo, Moscow.
132. ,, alternans, Buch.	,, -	River Petshora, Timan.
133. ,, Brightii, D'Orb. -	,, -	Skopin, Riazan.
134. ,, sublaevis, Sow. -	-	Telatma, Tambof.
135. ,, Koenigii, Sow. -	,, -	Koroshovo, Moscow.
136. ,, virgatus, Fisch. -	,, -	,, ,,
137. ,, catenulatus, Fisch.	,, -	,, ,,
138. ,, Kaschpuricus, Trautsch.	,, -	Syzran, Simbirsk.
139. ,, Ischmae, Keys. -	,, -	River Petshora, Timan.
140. ,, uralensis, D'Orb.	,, -	,, Sosva, Ural.
141. ,, Kirghisensis, D'Orb.	,, -	Saragul, Orenburg.
142. Belemnites absolutus, Fisch. -	,, -	Koroshovo, Moscow.
143. ,, curtus, Eichw. -	,, -	River Petshora, Timan.
144. ,, Panderianus, D'Orb.	,, -	Gorodishte, Simbirsk.
145. ,, magnificus, D'Orb.	,, -	,, ,,
146. ,, russiensis, D'Orb.	,, -	,, ,,
147. Pleurotomaria Bloedeana, D'Orb.	,, -	Koroshovo, Moscow.
148. ,, Buchiana, D'Orb.	,, -	,, ,,
149. Astarte Duboisiana, D'Orb. -	,, -	,, ,,
150 Lucina Phillipsii, D'Orb. -	,, -	Gorodishte, Simbirsk.
151. Lyonsia Alduini, D'Orb -	,,	Koroshovo, Moscow.
152 Panopaea peregrina, D'Orb. -	,, -	,, ,,
153 Pholadomya mediana, Eichw.	,, -	River Sosva, Ural.
154. Thracia Frearsiana, D'Orb	,, -	,, ,, ,,
155. Mytilus vicinalis, D'Orb. -	,, -	,, ,, ,,
156. ,, Strajevskianus, D'Orb.	,, -	,, ,, ,,
157. Lima consabrina, D'Orb.	,,	Koroshovo, Moscow.
158. Pinna sublanceolata, Eichw -	,, -	River Sosva, Ural
159 Avicula cuneiformis, D'Orb. -	,,	Koroshovo, Moscow.
160 Ancella mosquensis, Fisch. -	,, -	,, ,,
161 Gryphaea dilatata, Sow -	,, -	Telatma, Tambof.
162. Terebratula Rogeriana, D'Orb.	,, -	Koroshovo, Moscow.
163 ,, Fischeriana, D'Orb.	,, -	,, ,,
164. ,, Strogonofii, D'Orb.	,, -	River Sosva, Ural.
165. Rhynchonella varians, Buch	,, -	Telatma, Tambof.
166. ,, loxiae, Fisch.	,, -	Koroshovo, Moscow.
167. ,, oxyoptycha, Fisch	,, -	,, ,,
168. ,, grosse-sulcata, Eichw	,, -	River Sosva, Ural
169 Ammonites versicolor, Trautsch	Neocomian -	Simbirsk.
170. ,, discofalcatus, Lahus.	,,	,,
171. ,, fasciato-falcatus, Lahus.	,, -	,,

172. Ammonites elatus, Trautsch.	Neocomian -	Simbirsk.
173. Astarte porrecta, Buch. -	„ -	„
174. Avicula Cornueiliana, D'Orb.	„ -	„
175. Pecten crassitesta, Roem -	„ -	„
176. Inoceramus ancella, Trautsch.	„	„
177. Rhynchonella obliterata, Lahus.	„ -	„
178. Ancyloceras simbirskensis, Tazyk.	Gault -	„
179. Ammonites Deshayesii, Leym	„ -	„
180. „ bicurvatus, Mich.	„ -	„
181. Belemnitella mucronata, D'Orb.	Upper Chalk	Shilovka, Simbirsk.
182. Janira simbirskensis, D'Orb.	„ -	Tazykovo, „
183. Lima bistriata, Lahus. -	„ -	„ „
184. „ semisulcata, Desh. -	„ -	„ „
185. Pecten undulatus, Nils. -	„ -	„ „
186. Avicula lineata, Roem -	„ -	Simbirsk.
187. Inoceramus Cripsii, D'Orb. -	„ -	„
188. Ostrea semiplana, Sow. -	„ -	Maza, Simbirsk.
189. „ vesicularis, Lamk. -	„ -	„ „
190. Terebratula obesa, Sow. -	„ -	Tazykovo, Simbirsk.
191. „ carnea, Sow. -	„ -	„ „
192. Magas pumilus, Sow. -	„ -	„ „
193. Rhynchonella octoplicata, Sow.	„ -	„ „
194. Crania parisiensis, Defr. -	„ -	„ „
195. Ananchytes ovatus, Lamk. -	„ -	„ „
196. Nummulites distans, Desh. -	Eocene -	Simferopol, Crimea.
197. Buccinum baccatum, Bast. -	Miocene -	Stavrofka, Cherson.
198. Trochus podolicus, Dub. -	„ -	Kamenka, Podolia.
199. „ patulus, Brocc. -	„ -	Vishnevetz, Volhynia.
200. Turbo chersonensis, Barbt. -	„ -	Stavrofka, Cherson.
201. Cerithium disjunctum, Sow.	„ -	„ „
202. „ scabrum, Oliv. -	„ -	Potshaievo, Volhynia.
203. Natica millepunctata, Lamk. -	„ -	Vishnevetz, „
204. Mactra podolica, Eichw. -	„ -	Stavrofka, Cherson.
205. Ervilia podolica, Eichw. -	„ -	Kremenetz, Volhynia.
206. Tapes gregorea, Partsch. -	„ -	„ „
207. Lucina borealis, Lin. - -	„ -	Potshaievo, „
208. Pectunculus pilosus, Lin. -	„ -	Vishnevetz, „
209. Cardium obsoletum, Eichw. -	„ -	Stavrofka, Cherson.
210. „ protractum, Eichw.	„ -	Kremenetz, Volhynia.
211. „ Fittani, D'Orb. -	„ -	Kalfa, Bessarabia.
212. „ littorale, Eichw. -	„ -	Vosnessensk, Cherson.
213. Congeria simplex, Barbt. -	„ -	Gnilolofskaia, „
214. Ostrea digitalina, Eichw. -	„ -	Vishnevetz, Volhynia.

3362. Collection of Fossils from the Gault, &c. at Folkestone. *J. Starkie Gardner.*

Crustacea, including about 115 specimens of brachyura, 10 anomura, 115 macrura, mostly with limbs perfect. Several of the species are still undescribed. Gault coniferæ. Original specimens described by W. Carruthers, F.R.S.

Gault corals.

Grey chalk and gault echinoderms of the genera Cidaris, Pseudodiadema, Salenia, and allied genera.

Gasteropoda of the gault, illustrating the families aporrhaidæ, scalidæ, and rissoidæ, described in the Geological Magazine for 1875–76.

3363. Collection of Typical Trachytes, consisting of some fifty specimens, arranged according to the system of the contributor. *Dr. J. Szabo, Buda-Pesth.*

3364. Thin polished plates of Trachytes, prepared at the University Institute for microscopic observation.
Dr. J. Szabo, Buda-Pesth.

3365. Definition of Felspar exhibited in diagrams according to the system of the contributor.
Dr. J. Szabo, Buda-Pesth.

3366. Collection of Nummulites, systematically arranged with specimens prepared by Hantke and Madarász.
Maximilian Hantken, Buda-Pesth.

3367. General Collection of Foraminifera.
Maximilian Hantken, Buda-Pesth.

3368. Collection of Bryozoa, consisting of finished specimens. *Maximilian Hantken, Buda-Pesth.*

3369. Hammer Holder and Waist-strap; one with hammer in the position when worn. Specially adapted for geologists in the field. *Thomas J. Downing.*

3370. Card-board Trays, showing various sizes suitable for holding and arranging specimens in the cabinet.
Thomas J. Downing.

3371. Tablet-wood, covered with coloured papers, for mounting geological specimens. *Thomas J. Downing.*

3372. Improved Cement for mending fossils.
Thomas J. Downing.

3373. A collection of Volcanic Rocks of the Prussian provinces of Nassau and the Rhine, and especially from the district round the Laacher See and the Sieben Gebirge.
B. Stürtz, Bonn.

3374. A local collection of Trachytes from the neighbourhood of Kremnitz in Hungary. *B. Stürtz, Bonn.*

3375. A collection of Rock Specimens from the Island of Elba. *B. Stürtz, Bonn.*

3376. A collection of Volcanic Rocks from the neighbourhood of Naples. *B. Stürtz, Bonn.*

3377. A collection, for illustrating geological lectures, of 150 **Fossils**, in good condition, arranged according to the age of the formations in which they occur, and containing in systematic order the characteristic fossils of all the formations and most of their subdivisions. *B. Stürtz, Bonn.*

3378. A collection of 200 samples of different Lodes and specimens of Ores, from the mines of the mining district of Bonn. The ores are arranged systematically according to mineralogical system, and with their names, localities, peculiarities of the mines, and places of working; also showing the distribution and position of the lodes, and the quality of the ores.
B. Stürtz, Bonn.

3379. Impressions on large plates of **Extinct Species** of **Animals** (saurians and fish), suitable for illustrating the study of palæontology. *B. Stürtz, Bonn.*

3379. Collection of various kinds of Rocks, from different parts of Russia. 95 specimens. Value, 4*l.*
Mining School in St. Petersburg.

1. Granite. Serdobol, Finland.
2. „ (Rappa-Kivi). Wyborg, Finland.
3. Granite. Katharinenburg, Ural.
4. Green granite. Ilmen mountains, Ural.
5. Granite. Ilmen mountains, Ural.
6. Corundum-granite. Kyshtyn, Ural.
7. Gneiss. Katharinenburg, Ural.
8. „ Zlatoust, Ural.
9. „ River Wytim, Siberia.
10. Syenite. Bogoslovsk, Ural.
11. Uralite syenite. Turgoyak, Ural.
12, 13. Miascite. Ilmen mountains, Ural.
14. Diorite. Goroblagodatsk, Ural.
15. „ Miask, Ural.
16. Epidote-diorite. Olonetz.
17. Porphyrytic-uralite-diabasite. Katharinenburg, Ural.
18. Aphanitic-diabasite. Katharinenburg, Ural.
19. Green slate. Katharinenburg, Ural.
20. Oligoclase-hypersthenite. Valamo, Lake Ladoga.
21. Hornblendite. Goroblagodatsk, Ural.
22. Hornblendite, with zirkon. Miask, Ural.
23. Actinolite. Ufaleisk, Ural.
24, 25. Labradorite. Kamennoi Brod, Kiev.
26. Epidosite. Goroblagodatsk, Ural.
27. Garnet-rock. Turinsk, Ural.
28. Serpentine. Miask, Ural.
29. „ with diallage. Katharinenburg, Ural.
30. Schistose-serpentine. Katharinenburg, Ural.
31, 32. Beresite. Beresovsk, Ural.
33. Borsowite-rock. Kyshtym, Ural.
34. Mica-schist, with staurolite. Taganai, Ural.
35. Mica-schist, with garnet and staurolite. Taganai, Ural.
36. Mica-schist, with garnet and staurolite. Zlatoust, Ural.
37. Chlorite-slate. Werchneivinsk, Ural.
38. Chlorite slate, with tourmaline. Roshkino, Ural.
39. Talcoze-slate. Regewsk, Ural.
40. Listwenite. Ufoleisk, Ural.
41. Stacolumite. Voitzk, Archangel.
42. Quarz-porphyry. Isle Hoghland.
43. Felsite. Lake Aouschkul, Ural.
44. Variolitic-felsite. Altai, Siberia.
45. Orthoclase-labradorite porphyry. Isle Hoghland.
46. Hornblendic porphyry. Bogoslovsk, Ural.

Goroblagodatsk,

[illegible]clase-porphyry. Altai, Siberia.
49. Augite-porphyry. Blagodat, Ural.
50. Uralite-porphyry. Katharinenburg, Ural.
51. Oligoclase-diabasite porphyry. Aiatsk, Ural.
52. Felsitic-retinite (Kulibinite). Nertchinsk, Siberia.
53. Amorphic-trapp (Sordowalite). Serdobol, Finland.
54. Trachyte. Kasbek, Caucasus.
55. Hornblendic-andesite. Koktebel, Crimea.
56. Augite-andesite. Kasbek, Caucasus.
57. Andesitic-lava. Kasbek, Caucasus.
58. Obsidian. Goktcha, Caucasus.
59. Anamesite. Rowno, Volhynia.
60. Basalt. Goktcha, Caucasus.
61. Rock salt. Iletzk, Orenburg.
62. Marble. Gornoshitsk, Ural.
63. Limestone. Saoarka, Ural.
64. Oolite. Kamenka, Podolia.
65. Ophiocalcite. Kussinsk, Ural.
66, 67, 68. Dolomitic-marble. Tivdia, Olonetz.
69. Dolomitic-marble. Kapseiga, Olonetz.
70. Magnesite. Poliakovsk, Ural.
71. Porous quartz. Beresovsk, Ural.
72. Lydite with anthracite. Isle Volk, Lake Onega.
73. Hornstone with silver. Altai, Siberia.
74. Jasper. Lake Kalgan, Ural.
75. Jasper. Poliakovsk, Ural.
76. Magnetite. Blagodatsk, Ural.
77. Specular-iron-schist. Krivoi-Rog, Cherson.
Spathose-iron. Satkinsk, Ural.
79. Sphaerosiderite. Kromy, Orel.
80. Chromite. Ural.
81. Graphite. Tunkinsk, Siberia.
82. Graphite. Tunguska, Siberia.
83. Anthracite. Grushevka, Chain of the Donetz.
84. Coal. Chain of the Donetz.
85. Coal. Regewsk, Ural.
86. Coal. Tovarkova, Tula.
87. Boghead-coal. Muraievna, Riazan.
88. Iet. Tkvibul, Caucasus.
89, 90, 91. Sandstone. Shoksha, Olonetz.
92. Sandstone. Vytegra, Olonetz.
93. Apatite-sandstone. Kursk.
94. Apatite-sandstone. Tambof.
95. Alumstone. Zaglic, Caucasus.

II.—MINING.

3383. Ramsay's Water Gauge, for measuring the friction of ventilating currents in mines or other places.

D. P. Morison, Newcastle-on-Tyne.

The india-rubber tube is connected with the return airway of the mine, the other compartment of the apparatus being in communication with the external atmosphere; the friction, or difference of density of the two atmospheres, is indicated by the difference of level of the two columns of water. Advantages claimed are especially the facility of observation and the steadiness of the columns.

3384. Model of a Ventilator (Guibal).

Royal Saxon Mining Academy, Freiberg.

3385. Mining Barometer. *Elliott Brothers.*

3386. Mining Thermometer. *Elliott Brothers.*

3386a. Davis's Mining and Surveying Aneroid Barometer, reading altitudes to 1 foot. *John Davis and Son.*

nstrument is specially for the use of mining engineers and surveyors, ›urpose of readily ascertaining slight variations in gradients, levels, &c., m its extreme sensitiveness, will be found of considerable utility in ınd surveying work generally. Besides its extreme sensitiveness, the y claimed for the instrument is an arrangement of the scale of altitudes ìmits of subdivision by a vernier, hitherto impracticable, owing to the scale in ordinary use being a gradually diminishing one, to which a cannot be applied. In the present instrument the action has been so as to give accurate readings upon a regular scale of altitudes, the rical scale of inches being made progressive in length, so as to afford ect relative readings with the scale of altitudes. For mining opera- entire circle of the dial is graduated to represent 6 in. of the mer- olumn—that is, from 27″ to 33″. This scale affords observations out 2,000 ft. below sea level to 4,000 ft. above. The finest division ltitude scale (1-100th) represents 10 feet measurement, which can be vided by the vernier scale to single feet. The vernier scale is moved work adjustment, and a lens, which rotates on the outer circumference nstrument, facilitates the reading of minute quantities. For surface ıg purposes, where it is not required to be used below sea level, the nt is made with the scale divided from 25 to 31 in., thus giving an scale of 6,000 ft. above the sea level only; and with this open scale, assistance of the vernier, the same minute readings to single feet may taken. The instruments are also constructed for measuring much altitudes, that is 10,000, 15,000, or 20,000 ft., but with these scales the ment cannot be made quite so minute as in the more open scales. rument is 4½ inches in diameter, and is provided with a leather sling ıs making it sufficiently portable for all practicable purposes.

6b. Davis's Improved Colliery Barometer, specially l for moist climates. *John Davis and Son.*

ecessity of a travelling screw is dispensed with by choking partially the the tube, thus preventing the possibility of the mercury breaking the ıe tube by violent concussion in transit. The travelling screw (or the bottom for driving the mercury to the top of the tube) being dispensed cistern can be made entirely of boxwood. All the parts of the case l screwed together, thus making the instrument suitable for moist ıeres, such as pit banks.

7. Air Meter, used for the ventilation of mines and other uildings. *Francis Pastorelli.*

onsists of a horizontal box, with a dial, upon which are divided circles exes; this is mounted upon three vertical pillars, fixed into a brass ›lidly attached is a vertical ring; within this are eight vanes fixed to of a horizontal axis, the other terminating with an endless screw, orks a series of wheels in the box, and their revolutions are recorded ces on the dial; some of the working parts are jewelled to obtain imum amount of friction.

arge circle is divided into 100 parts which represent feet; one revolu- its hand is equal to 100 feet; now as the hand of the small circle times as slow, it is evident, that, while the former makes one complete on, the latter will only have made one-tenth of a revolution; therefore, has made one complete revolution, it will indicate 1,000 feet. The rcles are lettered hundreds, thousands, &c., up to 10 millions, and ed 1, 2, 3, 4, 5, 6, 7, 8, 9, 0.

ıeasuring an air current of a low velocity the readings on the large e taken, for a high velocity on both.

3387a. Improved form of **Air-meter** for use in coal mines, hospitals, &c. *E. Cette & Co., Holborn.*

3388. Patent Electric Velocimeter, for ascertaining the velocity of air currents in any part of the workings of a coal mine at a distance of two or more miles from it, in a chosen station above ground. *Francis Pastorelli.*

This consists of three parts:—

1. Four hollow hemispherical cups are fixed to the ends of four strong metal arms (at a distance of 90° apart) radiating from a central boss. At right angles to it is attached the horizontal axis, which is mounted in a rectangular metal box; each revolution of the cups causes a contact to be made.

2. The receiving instrument has a circular box with a dial mounted upon a metal base; it is worked by an electro-magnet; by its means each revolution of the cups is indicated, and motion given to a series of wheels. On the face of the instrument are divided circles and indexes, which register from 10, 100, 1,000 and so on up to 10,000,000 feet.

3. Attached to its side is a commutator, so that the current can be opened or closed for timing or other purposes; it is an ivory handle carrying an index, which can be moved to point to off or on at pleasure; it will also serve as a means to prevent unnecessary exhaustion of the battery.

4. A Lechlanché battery of six No. 2 cells is connected with the above, so that each revolution of the cups may be electrically transmitted and indicated on the large circle of the receiving instrument which represents 10 feet of velocity. The receiving instrument can be placed in any convenient position above ground. The cup arrangement (Dr. Robinson's with mechanical modifications) is intended to be used in the mine; in the air-ways or workings where the velocity of the air current is to be ascertained, its velocity is registered on the dials of the receiving instrument.

The inventor does not introduce this instrument with the idea that explosions will be prevented if it were generally adopted, but he has a strong impression that, by its use under proper regulations, it will be the means of diminishing them.

3388a. Signor Bianchi's Air Meter. *Conservatoire des Arts et Métiers, Paris.*

3388b. Air Meter. *L. Casella.*

THEODOLITES, COMPASSES, &C.

3390. Mining Compass, with independent vernier readings. *Patrick Adie.*

3390a. Casartelli's Improved Miners' Dial. *Joseph Casartelli.*

The first improvement (1861) consisted in mounting the sight-plate on axes cast on the compass-box, and attaching the arc for giving the angles of inclination to one of the axes, with the index so fixed as to be moved by the sight-plate when inclined to sight up or down the roads, and so give the angle of inclination. The second improvement (1874) consists in substituting a semi-circular limb fixed to the compass-box by pivots in the line N and S in such manner as not to obstruct the view through the sights. The degrees of angle are graduated on the face, and read off by indexes attached to the sight-

plate, which ride over the face of the semi-circle when the plate is inclined for the purpose of taking a sight in steep mines. When the arc is not required, it is simply folded down on the outside of the compass-box. In practice this is found to be an exceedingly convenient arrangement.

3390b. One 12-inch Circular Protractor, divided to 15 minutes for plotting in connexion with the dial.

Joseph Casartelli.

3391. Mine Compass, with arrangement for suspending needle 7 cm. long, circle graduated in degrees.

A. and R. Hahn, Cassel.

3392. W. König's Telescope Mine Compass, with level and graduated arc, together with Hörold's centre foot-plate in box with lock.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau).

This instrument is used by mine surveyors, and at official revisions of mine surveys.

3393. Complete Mine Surveying Implements, consisting of compass, suspender, graduated arc, additional plate, pocket and case for the additional plate. *Otto Fennel, Cassel.*

3394. Steel Measuring Band for mining surveyors, in case. *C. Osterland, Freiberg.*

Is devised to be used principally in conjunction with a mine theodolite constructed by the exhibitor, and is supposed to render skilled assistance in measuring of less importance to surveyors.

3395. Head with screw for the steel band.

C. Osterland, Freiberg.

3396. Travelling Box Compass, with brass support adapted for levelling with a small suspending apparatus, graduated arc, and appurtenances. *C. Osterland, Freiberg.*

Constructed for travellers in thinly populated countries, and is adapted for attaching to the saddle.

3397. Mine Surveying Instrument, consisting of compass, suspending apparatus, and additional plate, graduated arc, and two cases. *A. Lingke and Co., Freiberg, Saxony.*

3397a. Henderson's Hypo-theonite, with its stand, are improved forms of the same kind of instrument generally in use for rough surveying, especially in underground workings of collieries and other mines. *Ridley Henderson, Timsbury.*

3403. Two Maps with Photographs of mine surveying instruments. *C. Osterland, Freiberg, Saxony.*

3404. Small Theodolite, with repetition for mine surveyors.
A. Lingke and Co., Freiberg, Saxony (M. Hildebrand and E. Schramm).

3405. Compass Attachment to the Theodolite.
A. Lingke and Co., Freiberg, Saxony (M. Hildebrand and E. Schramm).

3406. Mine Theodolite with repetition, with—

a. Box compass.
b. Two separate tripods.
c. Two signals.
d. Two signal lamps.
e. Suspender and appurtenances to the compass.

F. W. Breithaupt and Son, Cassel (G. Breithaupt).

With horizontal circle 12 cm. in diameter, and silver border graduated into half degrees, the vernier indicating minutes and is covered with glass; the vertical circle and vernier are similarly divided, provided with transparent signals for use either below or above ground. The suspensory apparatus attached to the setting up compass was constructed by F. W. Breithaupt for the survey of the Hartz.

3407. Mining Theodolite, by Breithaupt and Son.
Royal High School of Industry at Cassel.

Mining Theodolite, with lateral telescope, constructed by F. W. Breithaupt and Son in 1864.—The two circles are divided upon silver and have, for the protection of the division, the covering also invented by Breithaupt, the verniers of which are closed with glass. The vertical circle is placed opposite to the telescope as a counterpiece. On the cylinder of the telescope axis a compass and a spirit-level can be placed. The spirit-level of the telescope serving for levelling lies with cylindrical pivots in bearers in front of the latter, and when the telescope is folded down it may be again turned upwards and observed. This theodolite also forms a convenient small universal instrument for astronomical observations. It has already been described in the fourth part of the "Magazin Mathematischer Instrumente," published by Breithaupt's establishment in the year 1860. A similarly constructed eccentric mining theodolite, referred to in 1876 by Prof. Bauernfeind, in his "Vermessungskunde," has been made by Ertel, of Munich.

Safety Lamps.

3407a. Davy's Original Safety Lamp. *Royal Society.*

and thus the inconvenience and loss of time involved in conveying lamps to the lamp-room on bank will be entirely obviated.

The locking arrangement, as will be seen, is extremely simple, and completely enclosed within the lamp, and protected from injury.

A number of these lamps can be opened in the time required to open one of the common locks, and a consideration of the accompanying engraving will at once convince the mining engineer of their superiority over every other lamp in use.

Every further information, and list of collieries where the lamps may be seen in use, can be obtained from G. P. Bidder, 24, Great George Street, Westminster, London, S.W., or from the makers.

The unlocking of these lamps by the apparatus for the purpose is very simple, and much more easily performed than with the ordinary key. The lock consists only of a piece of flat iron 2¾ inches by ¾ inch wide and ⅛ inch thick, to the end of which is attached the pin; this is kept in position by a strong spring underneath it, and projects into the upper rim of the lamp. It is impossible to unscrew the top until this pin is drawn by a powerful eight-bar magnet, the magnetism passing through the brass bottom, and drawing the pin down on the inside. If a large number of these lamps are required to be opened in a short time for cleaning, a set of electro-magnets, worked by a galvanic battery, placed in the lamp cabin is the most convenient arrangement.

3412. Apparatus for showing outwardly the mixture of gases existing in underground explorings. *M. Lemaire Douchy, Paris.*

2. Mining Models and Plans.

3413. Working Model of a proposed new system of Hand Drill for mining purposes. *Jos. P. O'Reilly, Dublin.*

The drill consists of the following parts:—

(1.) The bit, made in the model of those employed for artesian borings; it adapts itself by a screw to the

(2.) Barrel. This is of cast steel and tubular, thus allowing the passage of a stream of water through the bit into the hole. It is fitted with a bearing on its upper extremity on which plays the

(3.) Water box, the water passing through holes in the barrel from the box. The water box is kept from turning with the drill by means of

(4.) An armlet or ring passed on the arm, and connected with the box by a short connecting rod. The end of the barrel is terminated by

(5.) A solid head, changeable, when worn.

Each blow of the hammer drives the water into the hole with a pressure proportional to the force of the blow, thus clearing away the débris from the bottom of the hole, and keeping the cutting edge cool. The cutting edge, or bit, may be renewed frequently and easily without involving a change of drill, and the carriage of an equal number of drills, as at present.

3414. Two Plans, illustrating the principal modes of **working Coal** in the Yorkshire mining district. *Walter Rowley, C.E.*

Showing the advantages for economy of working and ventilation of the "Long Wall" system, and the disadvantages resulting from the "Pillar and Stall" mode of working.

SECTION 17.—MINERALOGY, CRYSTALLOGRAPHY, &c.

WEST GALLERY, UPPER FLOOR, ROOM M.

I.—APPARATUS, INSTRUMENTS, &c.

a. BLOWPIPE APPARATUS, &c.

3422. Blowpipe Apparatus for determining minerals. Case as supplied to the Arctic Expedition. *J. R. Gregory.*

3423. Plattner's original Blowpipe.
Royal Mining Academy, Freiberg, Saxony.

3424. Complete Blowpipe Apparatus, according to Plattner, consisting of a large case, with balance, instrument case, &c., re-agent case, charcoal box, balance case, and leather cover.
A. Lingke & Co. (Max Hildebrand and Ernst Schramm), Freiberg, Saxony.

3425. Cabinet of Apparatus and reagents, for blowpipe analysis. (Mineralogy.) *James How & Co.*

3426. "The Student's Pocket Blowpipe Case."
Thomas J. Downing.

This comprises the following necessaries, carefully selected for the student's use in the analysis of minerals: Blowpipe, candle, matches, charcoal, fluxes, acids, bone ash, mould for making cupel, anvil, hammer (handle loose), file, forceps, glasses for acids, streak plate, lens, platinum wire and foil, magnet, and glass tubes. Fitted in japanned tin case, with fastening, and adapted for the pocket.

3427. Collecting Bag for the geological and mineralogical collector. *Thomas J. Downing.*

3428. Mohs' Scale of Hardness. Nine minerals, with file, in polished case. *Thomas J. Downing.*

3429. Von Kobell's Scale of Fusibility. Six minerals, for determining the degrees of fusibility, in polished case.
Thomas J. Downing.

3430. Scale of Hardness.
Royal Mining Academy, Freiberg, Saxony.

intersections of the spiral with a divided straight edge parallel to the axis of the cylinder and in contact with it.

See Plate accompanying notice; Proc. Roy. Irish Acad., ser. II., vol. I., pl. XX. (The model represents the first form, since modified as in the plate.)

3439. Support for Crystal in the ordinary Wollaston **Goniometer,** on an improved principle.

Professor Jos. P. O'Reilly, Dublin.

This support is completely detached from the axis when the crystal is being mounted, offering, therefore, the greatest facility for this operation; it also brings the crystal outside the end of the axis, so that no part of the support can intervene between any face and the mirror underneath it.

3439a. A Simple Substitute for a **Goniometer.**

Professor W. H. Miller, Cambridge.

By means of this a crystal can be measured by Wollaston's method, and the angle of an edge determined by the determination of the angle between two lines drawn on paper along the wooden part of the instrument in its two different positions, by comparing the arc, intercepted by the two lines on a circle drawn through the point of intersection of the lines, with the whole circumference by means of compasses.

3440. Goniometer, with additional pieces of apparatus, by which it may be converted into an instrunnent for determining refractive indices, and an instrument for measuring the angle between the optic axes of biaxial crystals.

University of Oxford.

3441. Contact Goniometer, being the instrument used by the Abbé Haüy. *University of Oxford.*

It was formerly in the collection of Haüy's minerals, acquired by the late Duke of Buckingham. His Grace presented it to Dr. Buckland, by whom it was placed with the collection of minerals belonging to the University of Oxford, in which Dean Buckland was professor of mineralogy and geology. The Dean's autograph is on the morocco case.

3442. Goniometer, with horizontal circles, and adjusting level.

Professor Baron von Feilitzsch, Greifswald.

This reflective goniometer has a dividing circle of 7·5 inch diameter. The division runs direct as far as $\frac{1}{3}°$, and with the application of the nonius 0·5 minutes may be read. The instrument can likewise be used for spectrum experiments.

3443. Goniometer. *R. Fuess, Berlin.*

3443a. Goniometer. *M. Lutz, Paris.*

3443b. Goniometer, Wollaston. *M. Lutz, Paris.*

3443c. Goniometer, Babinet's. *M. Lutz, Paris.*

3444. Reflecting Goniometer, on marble slab, in mahogany case. *Georg Breithaupt, Cassel.*

A reflecting goniometer of the most perfect and improved construction. The circle is vertical, with a scale of 16 degrees in silver, the vernier giving readings to 10″. Diameter 21 centimeters, with lens, telescope, microscope, illuminating tube with prism, and arrangement for centering the crystals; also a lens for the objective of the telescope, &c. On a marble slab. Property of the K. K. Bergakademie of Leoben, in Styria.

3445. E. Mitscherlich's Goniometer.
Prof. A. Mitscherlich, Münden, Hanover.

A description of the goniomet[illegible]a in the memoir in "Berichte der königl. preussischen Akademie d[illegible]nschaften, 1873." E. Mitscherlich used this goniometer in much of his crystallographic work.

3446. Goniometer (made by Messrs. Powell and Lealand), with adjustments for mounting a crystal (as described in the introduction); and with fittings adapting it for the purposes, 1, of an instrument for determining refractive indices, and 2, for measuring the angle between the optic axes of biaxial crystals.
Prof. N. S. Maskelyne.

3446a. Goniometer, according to Börsch's principles; executed by Breithaupt and Son.
High School for Industry at Cassel (Dr. E. Gerland).

The goniometer—a deflecting goniometer, according to Babinet—can be altered into a spectrometer by affixing a prism. It has the advantage that all examinations and corrections on it can be effected without special auxiliary means, as well as all angles; refraction coefficients can be found by two entirely different methods. (See Borsch, Poggend. Ann., vol. CXXIX., p. 384.)

3447. Polarising Apparatus, with telescope tube and goniometer. *Wilhelm Steeg, Homburg, Prussia.*

3448. Brezina's Stauroscope.
Wilhelm Steeg, Homburg.

3449. P. Groth's Universal Apparatus for Crystallographic Optical research. *R. Fuess, Berlin.*

Vide "Physikalische Krystallographie," by Professor P. Groth, Leipzig, Engelmann, 1876

3450. "Microgoniometer," for measuring with the microscope. *Prof. Friedrich Pfaff, Erlangen.*

The arc which stands horizontally can also be placed so that it can be used for vertical measurements. A small pamphlet on the instrument accompanies it.

3451. Charles' original Goniometer.
Conservatoire des Arts et Métiers, Paris.

3453. Apparatus for studying and exhibiting the Optical Characters of Crystals.

3454. Instruments of Observation.
Three prisms for demonstrating the different dispersions of axes in crystals.
Tourmalin pincers (Tourmalin or Lyncurium).
Andalusite pincers.
Prism of dense flint; Rossette substance.
Dichroïsmal lens.
M. Werlein, Paris.

II.—COLLECTIONS OF MINERALS, DIAGRAMS, MODELS OF CRYSTALS, &c.

a. Rocks and Minerals.

3455. Microscopic Sections of rocks and minerals.
J. R. Gregory.

3456. "Explorer's Comparison Mineralogical Cabinet."
J. R. Gregory.

3457. Rough Gems and Precious Stones, in their natural form and condition, 15 varieties; useful to travellers for the purpose of comparison and testing. *Thomas J. Downing.*

3458. Specimens of **transparent** slices of various **Minerals** for the **Microscope.**
Royal Polytechnic School at Delft, Prof. S. Bosscha.

a. Specimens of minerals described in Prof. Vogelsang's work, "Die Philosophie der Geologie," Bonn, 1867, and depicted on Tables I. and III.
b. Specimens of crystallites described in "Archives Neerlandaises des Sciences Physiques et Naturelles," and depicted in Table VII. of Vol. V., and Table III. of Vol. VI., and in Prof. Vogelsang's posthumous work, "Die Kristalliten," edited by Prof. F. Zirkel, Bonn, 1875.
c. Quartz slices with cavities containing fluid carbonic acid.

3459. Thin Sections of Minerals.
Ludwig Möller, Giessen.

3460. Collection of rare and remarkable specimens of **Zinc Ores** from the north of Spain, and from the county Tipperary, Ireland, to illustrate the modes of occurrence and formation of hydrated silicates and carbonates, particularly the oolitic and imitative forms. *Professor Jos. P. O'Reilly, Dublin.*

3461. Photographs (4) of imitative shapes presented by certain hydrated silicates and carbonates of **Zinc** in the collection from the north of Spain. *Professor Jos. P. O'Reilly, Dublin.*

3462. Sections or Diagrams illustrative of **Zinc Ore** deposits of silver mines, county Tipperary, Ireland.
Professor Jos. P. O'Reilly, Dublin.

3463. Collection of Sections of Crystals, for exhibiting in the Polariscope. *Dr. Stone.*

3464. Specimens of Minerals prepared for Observation.

Case containing minerals and chemical products.
Case containing specimen of micrographic rock.
Four cubes of different chroïtes crystals.
Rhomboïd in Iceland spar.
Section of a diorite.

M. Werlein, Paris.

3465. Collections of Cryst: ls and Minerals.

B. Stürtz, Bonn.

3465a. Collection of Crystals. *M. Lutz, Paris.*

3466. A collection of 200 separate Crystals, for mineralogical and crystallographical study; their faces have been crystallographically determined; the system of crystallography used is that of Naumann. *Bernh. Stürtz, Bonn.*

3467. Specimens from **Mitscherlich's** collection of **Artificial Minerals,** Felspar, Magnetic Iron Ore, &c.

Prof. A. Mitscherlich, Münden, Hanover.

3468. Specimens of Mica containing tourmalin, garnet, and quartz. *Max. Raphael, Breslau.*

3469. Collection of **Plates of Crystals, Selenite, and Mica** combinations, **Dichroiscope,** cubes and plates for showing dichroism; about 180 pieces in mahogany case.

Wilhelm Steeg, Homburg.

In the collection of plates of crystals are a large number of beautiful, rare, and valuable minerals and chemical preparations, which in part show, besides polarisation figures, also dichroism, atterism, fluorescence, &c. Also preparations exhibiting interesting twin growths in closed crystals, and crystals containing liquids in cavities.

3469a. Russian Minerals taken from the educational collection in the Mining School in St. Petersburg. 417 specimens, value, 180*l*. *Mining School in St. Petersburg.*

1, 2. Gold. Zmeinogorsk, Altai.
3. Silver Zmeinogorsk, Altai.
4. „ Salair, Altai.
5. „ Nikolaievsk, Altai.
6. „ Urjum, Siberia.
7, 8, 9. Copper. Nishni-Turünsk, Ural.
9*a* Platinum. Nishni-Tagilsk, Ural.
9*b*. Iridosmine (Newjanskite). Zlatoust, Ural.
10, 11. Meteoric iron (Pallasite). Krasnoiarsk, Siberia.
11 *bis*. Tin Yenisseisk, Siberia.
12. Aerolite. Pultusk, Sedletz.
13. Native sulphur. Kazan
14, 15. Graphite. Serdobol, Finland.

16. Graphite. Ilmen mountains, Ural.
17, 18. Graphite. Tunkinsk mountains, Irkutsk.
19. Stibnite. Serentujevsk, Nertchinsk.
20. Molybdenite. Pitzaranta, Finland.
21. Molybdenite. Ilmen mountains, Ural.
22. Galenite. Zadonsk, Caucasus.
23. Tellursilver. Zavodinsk, Altai.
24. Bornite. Nishni-Tagilsk, Ural.
25. Sphalerite or Blende. Klitchkinsk, Nertchinsk.
26. Chalcosite. Olonetz.
27, 28. Chalcosite. Nishni-Turünsk, Ural.
29. Cinnabar. Ildikansk, Nertchinsk.
30. Pyrrhotite. Ersby, Finland.
31, 32, 33, 34. Pyrite. Pitkaranta, Finland.
35. Pyrite. Riazan.
36. Chalcopyrite. Beresovsk, Ural.
37. Jamesonite. Algatchinsk, Nertchinsk.
38. Pyrargyrite. Zmeinogorsk, Altai.
39. Tetrahedrite. Beresovsk, Ural.
40. Patrinite. Beresovsk, Ural.
41. Rock salt. Astrakhan.
42. Cerargyrite. Zmeinogorsk, Altai.
43. Embolite. Michailovsk, Orenburg, Ural.
44, 45, 46. Fluorite. Kadainsk, Nertchinsk.
47. Fluorite (Ratofkite). Iver.
48. Chiolite. Ilmen-mountains, Ural.
49. Cuprite. Nishni-Tagilsk, Ural.
50. Chalcotrichite. Gumeshevsk, Ural.
51. Hepatinery (Liver-ore). Nishni-Turünsk, Ural.
52. Minium. Michailovsk, Nertchinsk.
53, 54, 55. Corundum. Ilmen mountains, Ural.
56, 57. Corundum (Soimonite). Soimonovsk, Ural.
58, 59. Hematite. Gornoshitsk, Ural.
60. Hematite. Polekovsk, Ural.
61, 62. Ilmenite. Ilmen mountains, Ural.
63, 64. Perofskite. Achmatovsk, Ural.
65. Perofskite. Nicolai Maximilianovsk, Ural.
66, 67, 68, 69. Chlorospinel. Shishimsk mountains, Ural.
70. Magnetite. Achmatovsk, Ural.
71. „ Shishimsk mountains, Ural.
72. Magnetite. Lupiko, Finland.
73. „ Zlatoust, Ural.
74. Chromite. Ufaleisk, Ural.
75. „ Bilimbaievsk, Ural.
76. Chrysoberyl (Alexandrite). Katharinenburg, Ural.
77. Cassiterite. Pitkaranta, Finland.
78, 79, 80. Cassiterite. Onon, Siberia.
81. Rutile. Kossoi-Brod, Ural.
82. „ Sissertsk, Ural.
83. „ Sanarka, Miask, Ural.
84. Brookite. Kamenka, Miask, Ural.
85. Diaspore. Kossoi-Brod, Ural.
86. Göthite. Volk Ostrov, Olonety.
87, 88, 89. Limonite. Beresovsk. Ural.
90. Limonite. Orel.
91. Hydrargillite. Shishimsk mountains, Ural.
92. Bismuthite. Beresovsk, Ural.
93. Quartz (Rhombohedron). Volk-Ostrov, Olonetz.
94, 95. Quartz. Neviansk, Ural.
96, 97. „ Serapulka, Ural.
98. Quartz, with green Turmalin. Beresovsk, Ural.
99. Quartz (Yellow). Neviansk, Ural.
100. Quartz (Smoky). Neviansk. Ural.
101, 102. Quartz (Smoky). Mursinsk, Ural.
103, 104, 105. Amethyst. Lipovaia, Ural.
106. Avanturine. Tesma, Zlatoust, Ural.
107. Chalcedony. Kamtchatka.
108. „ Tshikoi, Nertchinsk.
109. Carnelian. Shilka, Nertchinsk.
110. Chrysoprase. Kishtym, Ural.
111. Heliotrope. Orsk, Orenburg.
112. Jasper. Korgon, Altai.
113. Jasper. Revnevaia-gora, Altai.
114. Jasper. Dutsharsk, Nertchinsk.
115. Opal Kiev.
116. Tripolite. Simbirsk.

117. Wollastonite. Pargass (Ersby), Finland.
118, 119, 120. Diopside. Achmatovsk, Ural.
Baikalite. Sludianka, Baikal.
121 bis. Vanadinaugite (Lawrowite). Sludianka, Baikal.
122, 123. Rhodonite. Schabrovaia, Ural.
124, 125, 126. Pargasite. Pargass (Ersby), Finland.
127. Tremolite. Verchneivinsk, Ural.
128. Koksharowite. Sludianka, Baikal.
129. Asbestos. Miask, Ural.
130. Sordawalite. Serdobol, Finland.
131. Pitkarantite. Pitkaranta, Finland.
132, 133, 134. Beryl. Mursinsk, Ural.
135. Beryl. Tigiretsk, Altai.
136 ,, Adun-Tchilon, Nertchinsk.
137. Beryl. Ubrulga, Nertchinsk.
138 ,, Onon Siberia.
139 ,, Tammela, Finland.
140. Emerald. Katharinenburg, Ural.
141. Chrysolite (Glinkite). Itkul, Ural.
142, 143. Phenacite. Katharinenburg, Ural.
144, 145. Phenacite. Ilmen mountains, Ural.
146. Helvine. Ilmen mountains, Ural.
147. Achtaragdite. Achtaragda (Wilui), Siberia.
148, 149. Grossularite. Wilui, Siberia.
150. Almandine. Taganai, Zlatoust, Ural.
151, 152. Garnet. Achmatovsk, Ural.
153. Garnet. Talaia, Siberia.
154, 155, 156. Melanite. Pitkaranta, Finland.
157. Melanite. Achmatovsk, Ural.
158, 159, 160, 161, 162. Zircon. Ilmen mountains, Ural.
163. Auerbachite. Masurenko, Ekatherinoslav.
164, 165. Malacone. Ilmen Mountains, Ural.
166. Vesuvianite. Lupiko, Finland.
167. Frugardite. Frugard, Finland.
168. Vesuvianite. Achmatovsk, Ural.
169. Vesuvianite (Perimorphose). Achmatovsk, Ural.
170. Vesuvianite. Poliakovsk, Zlatoust, Ural.
171. Vesuvianite. Medvedjeva, Zlatoust, Ural.
172. Heteromerite. Shishimsk mountains, Ural.
173. Wilnite. Wilui, Siberia.
174, 175. Epidote. Kumbaksea, Olonetz.
176. Epidote. Heponselga, Finland.
177. ,, Sillböhle, Helsinge, Finland.
178, 179. Epidote. Achmatovsk, Ural.
180. Puschkinite. Verchneivinsk, Ural.
180 bis. Bucklandite. Achmatovsk, Ural.
181. Orthite. Werchoturie, Ural.
182, 183, 184. Uralorthite. Ilmen mountains, Ural.
185. Nephrite. Sludianka, Baikal.
186. Axinite. Kumbaksea, Olonetz.
187, 188. ,, Berkutovaia-gora, Ural.
189, 190, 191. Steinheilite. Kisko, Orrijervi, Finland.
192. Gigantolite. Tammela, Finland.
193. Pyrargillite. Helsingfors, Finland.
194. Mica (biaxial). Kimito, Finland.
195. Mica (biaxial). Alabashka, Ural.
196. Lepidolite. Schaitanka, Ural.
197. ,, Serapulka, Ural.
198, 199, 200. Mica (biaxial). Ilmen mountains, Ural.
201. Fuchsite. Kossoi-Broel, Ural.
202. Diphanite. Katharinenburg, Ural.
203, 204, 205. Biotite. Sludianka, Baikal.
206, 207, 208. Wernerite. Laurinkari (Åbo), Finland.
209. Wernerite. Pargass (Ersby), Finland.
210, 211. Stroganowite. Sludianka, Baikal.

212, 213. Glaukolite. Sludianka, Baikal.
214. Elacolite. Ilmen mountains, Ural.
215, 216. Cancrinite. Ilmen mountains, Ural.
217. Sodalite. Ilmen mountains, Ural.
218, 219, 220, 221. Lapis Lazuli. Sludianka, Baikal.
222. Lepolite (Anorthite). Karis-Lojo, Finland.
223. Lepolite. Karis-Lojo, Finland.
224. Lindsayite. Kisko, Orierví, Finland.
225. Labradorite. Oisuno, Lojo, Finland.
226. Labradorite. Urpala, Sakkiervi, Finland.
227. Labradorite. Rodomisl, Kiev.
228. Oligoclase. Turholm, Helsinge, Finland.
229. Oligoclase. Kyrkslatt, Esbo, Finland.
230. Oligoclase. Stansvik, Helsinge, Finland.
231. Oligoclase. Katharinenburg, Ural.
232. Albite. Nishni Tagilsk, Ural.
233. „ Mursinsk, Ural.
234. „ Alabashka, Ural.
235, 236, 237. Albite. Kiriabinsk, Zlatoust, Ural.
238, 239. Orthoclase. Alabashka, Ural.
240, 241. Orthoclase. Mursinka, Ural.
242, 243. Amazonstone. Ilmen mountains. Ural.
244. Orthoclase. Miakoticha, Altai.
245. „ (Sunstone). Sludianka, Baikal.
246. Adularia. Mursinsk, Ural.
247. Marekanite. Marekanka, Ochotsk.
248. Nefedjewite. Klitshkinsk, Nertchinsk.
249. Chondrodite. Pargass (Ersby), Finland.
250. Tourmaline. Beresovsk, Ural.
251, 252, 253. Tourmaline. Mursinsk, Ural.
254. Tourmaline. Schaitansk, Ural.
255, 256. Tourmaline. Borstchevatchnoi, Nertchinsk.
257, 258. Tourmaline. Ubrulga, Nertchinsk.
259, 260. Tourmaline. Mursinsk, Ural.
261. Tourmaline. Gornoshitsk, Ural.
262. Tourmaline. Adun Tethilon, Nertchinsk.
263. Andalusite. Schaitansk, Ural.
264. „ Tut Chaltovi, Nertchinsk.
264 *bis*. Chiastolite. Argan, Nertchinsk.
265. Xenolite. Peterhoff, St. Petersburg.
266. Wörthite. Peterhoff, St. Petersburg.
267. Cyanite. Taganai, Zlatoust, Ural.
268. Cyanite. Kishtym, Ural.
269. „ Sanarka, Ural.
270. „ Kamenka, Ural.
271, 272, 273. Topaz. Mursinsk, Ural.
274, 275, 276. Topaz. Ilmen mountains, Ural.
277, 278. Topaz. Adun Tchilon. Nertchinsk.
279. Topaz. Bortstchevotchnoi, Nertchinsk.
280. Sphene. Pargass (Ersby), Finland.
281. Sphene. Achmatovsk, Ural.
282, 283. Sphene. Ilmen mountains, Ural.
284. Sphene. Kazatchia Datcha. Ural.
285. Staurolite. Taganai Zlatoust, Ural.
286. Laumontite. Petropavlovsk, Ural.
287, 288, 289. Dioptase. Altyn Tübeh, Kirghistan Steppe.
290. Chrysocolla. Nishni Turünsk, Ural.
291. Chrysocolla. Nishni-Tagilsk, Ural.
292. Asperolite. Nishni-Tagilsk, Ural.
293. Picrosmine. Miask, Ural.
294. Calamine. Taininsk, Nertchinsk.
295. Calamine. Klitshkinsk, Nertchinsk.
296. Prehnite. Schaitansk, Ural.
297. Apophyllite. Piterlaks, Wiborg.
298. Natrolite. Tchikoi, Nertchinsk.
299. Analcime. Kulinda, Nertchinsk.
300. Chabazite. „ „

301. Stilbite. Bielaia, Nertchinsk.
302. Talc. Itkul, Perm.
303, 304. Pyrophyllite, Beresovsk, Ural.
305. Cimolite. Alexandrovsk, Ekathermoslav.
306. Pelikanite. Kiev.
307. „ Lupiko, Finland.
308. Serpentine. Nurali, Miask, Ural.
309. Pinite with chlorite. Shishimsk mountains, Ural.
310, 311, 312. Leuchtenbergite. Shishimsk mountains, Ural.
313. Kämmererite. Bisersk, Ural.
314, 315. Rhodochrome. Itkul, Perm.
316, 317, 318, 319, 320. Clinochlore. Achmatovsk, Ural.
321. Clinochlore (pseud. Ceylanite). Nicolai Maximilianovsk, Ural.
322. Kotschubeite. Ufaleisk, Ural.
323. Kotschubeite. Bilimbaievik, Ural.
324. Chloritoid. Kossvi-Brod, Ural.
325. Xanthophyllite. Shishimsk mountains, Ural
326. Xanthophyllite. Nicolai, Maximilianovsk, Ural
327, 328. Pyrochlore. Ilmen mountains, Ural
329. Tantalite. Kimito, Finland.
330. Columbite. Pyio, Finland
331, 332, 333. Samarskite. Ilmen mountains, Ural.
334. Mengite. Ilmen mountains, Ural.
335. Apatite. Pargass (Ersby), Finland
336, 337. Apatite. Katharinenburg, Ural.
338. Talcapatite. Shishimsk mountains, Ural.
339. Pseudoapatite. Shishimsk mountains, Ural.
340. Apatite. Ilmen mountains, Ural
341, 342. Moroxite. Sludianka, Baikal.
343. Lazur-apatite. Sludianka, Baikal.
344, 345. Pyromorphite. Beresovsk, Ural.
346. Mimetesite. Beresovsk, Ural.
347, 348. Monazite. Ilmen mountains, Ural.
349. Vivianite. Kertsch, Crimea
350. „ Bargusin, Nertchinsk.
351. Libethenite. Nishni, Tagilsk, Ural.
352, 353. Pseudomalachite. Nishni, Tagilsk, Ural.
354. Dihydrite. Nishni, Tagilsk, Ural.
355. Planerite. Sissertsk, Tschernoia, Ural.
356. Hydroboracite. Caucasus.
357. Borax. Baikal.
358, 359. Wolframite. Adun, Tchilon, Nertchinsk.
360. Hübnerite. Baiiovka (Bogoriak), Ural.
361, 362. Scheelite. Pitkaranta, Finland.
363, 364. Vanadinite. Beresovsk, Ural.
365. Volborthite. Preobrashensk, Perm.
366, 367. Thenardite. Marmishansk, Altai.
368, 369, 370. Barite. Kusinsk, Ural.
371. Barite. Gasimurovsk, Nertchinsk.
372. Celestine. Archangel.
373, 374, 375. Crocoite. Beresovsk, Ural.
376. Vauquelinite. Beresovsk, Ural.
377, 378. Gypsum. Astrakhan.
379. Gypsum. Bugulma, Samara.
380. „ Tetushi, Kazan
381. Alunite. Zaglik, Caucasus.
382. Brochantite. Gumeshevsk, Ural.
383. Brochantite. Zyrianovsk, Altai.
384, 385. Calcite. Ural.
386. Calcite. Mulina, Nertchinsk.
387. „ Volk-Ostrov, Olonetz.
388. Calcite. Pavlovsk, St. Petersburg.
389. Calcite. Tmatra, Finland.
390. Dolomite. Pargass (Ersby), Finland.
391. Dolomite. Katharinenburg, Ural.
392. Gurhofian. Orenburg.
393. Siderite. Ural.
394. Sperosiderite. Ural.
395. Smithsonite. Tchagirsk, Altai.
396, 397. Smithsonite. Kadainsk, Nertchinsk.
398. Aragonite. Nishni, Turinsk, Ural.

399. Cerussite. Riddersk, Altai.
400. „ Taininsk, Nertchinsk.
401. Cerussite. Kadainsk, Nertchinsk.
402. Cerussite. Ildikensk, Nertchinsk.
403. Witherite. Zmeinogorsk, Altai.
404. Malachite. Gumeshevsk, Ural.
405. Malachite. Nishni, Tagilsk, Ural.
406. Malachite. Beloussovsk, Altai.
407. Aurichalcite. Zavodinsk, Altai.
408. Azurite. Nikolaievsk, Altai.
409. „ Semenovsk, „
410. „ Zyrianovsk, „
411, 412. Mellite. Malevka, Tula.

3470. I. Sphere of Calcite, 3¼ inches in diameter.

II. Polyhedron of Calcite, cut from a large rhombohedron of that mineral, so as to represent the optical characters of the crystal in directions perpendicular,—

1. To the pinakoid, and along the optic axis.
2. To a prism plane, and perpendicular to the optic axis.
3. To the cleavage planes (of the rhombohedron) (100).
4. To the plane (122) correlative to the cleavage rhombohedron.

(These were made by Mr. Ahnens.) *Prof. N. S. Maskelyne.*

3471. Collection of Crystals of Minerals. *J. R. Gregory.*

3472. Nicol's Prism, whose side is about 60 millimeters. *Wilhelm Steeg, Homburg.*

3473. Prism of Rock Salt, 50 x 60 mm. *W. Steeg, Homburg vor der Höhe.*

3474. Lens of Rock Salt, 75 mm. thick, and 300 mm. in radius. *W. Steeg, Homburg vor der Höhe.*

3475. Plate of Rock Salt, 60 x 60 mm. *W. Steeg, Homburg vor der Höhe.*

3476. Calcspar Rhombohedron, with glasses ground parallel and perpendicular to the axis. *Wilhelm Steeg, Homburg.*

3477. Calcspar Prism, with plane parallel to the axis. *Wilhelm Steeg, Homburg.*

3478. Piece of **Sulphur** with **large Crystals.** *Prof. A. Mitscherlich, Münden, Hanover.*

E. Mitscherlich by these crystals of sulphur determined the crystalline form of the sulphur from the molten condition, and discovered the dimorphism of sulphur.

b. Models and Diagrams of Crystals, Rocks, Minerals, &c.

3479. Diagrams and Microscopic Slides, demonstrating the structure of Bohemian Basalt.

1. Diagram representing the most important types of Bohemian Basalt. On six plates.
2. Diagram showing the most important types of Phonolite, Trachybasalt, Trachylitbasalt, and Melaphyr rocks. On four plates.
3. Two boxes containing 10 microscopical preparations of the above-mentioned rocks.
4. Professor Boricky's works on the Basaltic and Phonolithic rocks of Bohemia, with short explanation of the Melaphyr illustrations. *Dr. Emanuel Borricky, Prague.*

3480. Photograph of the Rittersgrün Meteorite.
Royal Mining Academy, Freiberg, Saxony.

3481. Wall Map of the Natural History of the **Mineral Kingdom,** by Dr. G. Seelhorst. *P. C. Geissler, Nürnberg.*

The wall map consists of coloured plates, which are mounted on linen, with a portfolio in which to keep the map when not hanging on a wall. The text is printed on both sides of the map. The map is constructed to fold up in the portfolio, as well as to hang on a wall, and consists of one sheet.

3482. Diagrams (four), or "Pictures," illustrative of **Applications of Descriptive Geometry to Crystallography,** viz.: two illustrating derivation of holohedral and hemihedral tesseral forms; and two showing construction of crystal projections from angular measurements and from crystallographic formulæ.
Prof. Jos. P. O'Reilly, Dublin.

3483. Model, mounted with movable arcs and core, for demonstration of the fundamental forms in each crystalline system, and of the geometric method of derivation of the different holohedral and hemihedral forms from the fundamental one in each system.
Prof. Jos. P. O'Reilly, Dublin.

The model possesses a movable core adapting itself to the six systems and use of elastic cords to represent the intersections and edges of forms.

3484. Seven Wire Models representing the symmetry of five of the crystallographic systems (made by Mr. Sparrow of the British Museum for Prof. Maskelyne). *Prof. Maskelyne, F.R.S.*

These models represent the great circles in which the sphere of projection is intersected by the planes of symmetry characteristic of the different crystalline systems; each plane of symmetry being subdivided by a network of wires intersecting at distances proportionate to the parametral ratios of some crystal belonging to the particular system. They are—

I. The cubic system.
II. The hexagonal system represented—
  1. By quartz.
  2. By calcite
  3. By tourmaline.
III. The tetragonal system represented by apophyllite.
IV. The prismatic system represented by barytes.
V. The oblique system.

3485. Diagrams illustrative of the **Cubic System of Crystallography,** painted to match the models.
Rev. Nicholas Brady, M.A.

These give the general position on the sphere of projection of all the chief varieties of the species in the system. Examples of the different species, both holohedral and hemihedral, in orthographic perspective, in projection on the plane of the paper, and giving the position of their poles on the sphere of projection, with similar drawings for twin crystals, drawn by contributor.

3486. Series of Twelve Water-colour Drawings, illustrative of the **Optical Phenomena** seen in sections of **Minerals** cut perpendicular to the optic axis or axes of the crystal under the influence of polarized light. Drawn by contributor.
Rev. Nicholas Brady, M.A.

PYRAMIDAL AND RHOMBOHEDRAL SYSTEMS.—UNIAXIAL.

1. Calcite negative plane polarized analyzer and polarizer parallel.
2. „ „ „ „ 45° apart.
3. „ „ „ „ 90° „
4. „ elliptically polarized „ 45° „
Axis of $\frac{1}{4}$ wave film inclined about $22\frac{1}{2}°$ to plane of polarizer.
5. Quartz rotary polarization. Analyzer and polarizer. 90° apart.
6. Two similar plates of quartz superposed, the lower showing left-handed rotary polarization, the upper right-handed analyzer and polarizer, 90° apart. This phenomenon is known as *Ary's spirals.*
7. Quartz circularly polarized analyzer and polarizer, 90° apart, and axis of $\frac{1}{4}$ wave film 45° from plane of polarizer.

PRISMATIC OBLIQUE AND ANORTHIC SYSTEMS.—BIAXIAL.

8. Nitre plane polarized analyzer and polarizer, parallel line joining optic axes = to polarizer.
9. Nitre plane polarized analyzer and polarizer, 45° apart, line joining optic 45° from polarizer.
10. Nitre plane polarized analyzer and polarizer, 90° apart, line joining optic 45° from polarizer.
11. Nitre plane polarized analyzer and polarizer, 90° apart, line joining optic parallel to polarizer.
12. Organite optic axes, widely separated, only one is seen, analyzer and polarizer 90° apart, line joining optic axes parallel to polarizer.

3487. Large Wire Model, containing one example of each species of simple form in the cubic system of crystallography, with its corresponding hemihedral forms inscribed within a sphere of the chief zone circles of the system. *Rev. Nicholas Brady, M.A.*

The coloured wires indicating the junction of the faces are painted as follows: Cube, vermillion; octahedron and tetrahedron, French blue; dodecahedron, emerald green; three-faced octahedron and 12-faced scalenohedrons, deep cadmium yellow; 24-faced trapezohedron and three-faced tetrahedrons, burnt sienna; four-faced cube and pentagonal dodecahedrons, violet carmine; six-faced octahedron and six-faced tetrahedrons and irregular 24-faced trapezohedrons, Schele's green. On the several zone circles are marked the position of all the poles of the chief forms of the cubic system, except those of most of the forms of k.k.l., or six-faced octahedron, which lie in the triangles made by the zone circles. This model contains more than 700 wires soldered together. Made by contributor.

All these above forms are shown in solid in their corresponding colours in the accompanying large series of models of the cubic system, and are drawn in plan and perspective on a series of diagrams similarly coloured.

The particular forms contained in this model are 100.111 + and $-\kappa$111. 110.122. + and $-\kappa$ 122.112. + and $-\kappa$ 112.210 + and $-\pi$ 210.531 + and $-\pi$ 351 + and $-\kappa$ 351. Miller's Terminology.

3488. Collection of Models of the Cubic System of Crystallography, to a scale of three inches for the circumscribing cube, made in cardboard, and painted according to their simple forms. *Rev. Nicholas Brady, M.A.*

These comprise all the chief varieties of the several species, both holohedral and hemihedral, together with the chief combinations of the principal examples of each simple form, with the cube, octahedron, tetrahedron, and rhombic dodecahedron, fully illustrating the passage of one combination to another. In this series the positive and negative hemihedral forms and their orientation are denoted by the dark and light tints of the same colour.

3489. Collection of three-inch **Models** of the regular **Platonic Solids,** the only forms possible with equilateral sides, and equi-angular with the simple forms from which they are respectively derived. Made by contributor. *Rev. Nicholas Brady, M.A.*

3490. Set of Regular Octahedral Models, showing that crystalline form depends upon the number and parallelism of parts, and not upon the mere shape of the face. Made by contributor.
Rev. Nicholas Brady, M.A.

3491. Set of three-inch **Models** of the **Pyramidal System of Crystallography,** giving the ief simple forms of the minerals of the system, with the latitud f their poles. Made by contributor. *Rev. Nicholas Brady, M.A.*

3492. Collection of Models the Rhombohedral System of Crystallography, with its h ohedral, hemihedral, and tetrahedral forms, showing their orientation and combination with the form 111 written. Made by contributor.
Rev. Nicholas Brady, M.A.

3493. Large Models of Crystals, for lecture illustration.
Professor Crum Brown, University of Edinburgh.

The models are made of pasteboard, and painted. Six models are sent—(1) Rhombic Dodecahedron, and (2) Pentagonal Dodecahedron, illustrating the relation of these forms to the cube; (3) and (4), Dextro and Laevo-tartaric acid; (5) Double laevo-tartrate of soda and ammonia; (6) Asparagine.

3494. Collection of 114 **Models of Crystals,** in wood.
Heinrich Piel, Bonn.

3495. Collection of 100 **Models of Crystals,** in wood, to illustrate the most important chemical compounds.
Heinrich Piel, Bonn.

3496. Complete collection of **Models of Crystals,** 300, in three boxes. *Heinrich Piel, Bonn.*

3497. Collection of 30 **Models of Crystals,** of complicated forms. *Heinrich Piel, Bonn.*

The whole of the collections of the models of crystals have been carefully prepared by hand, without the aid of machinery.

The models of these collections have an average diameter of section of 5 centimeters; if required, the models may also be procured of a section of 10 centimeters, by which the price would be proportionately increased. Besides complete collections of any desired size and number, single models may also be obtained, the price of which will depend on the number of faces and the difficulty of their manufacture. If desired, stands may be obtained. Stands may be procured for exhibiting the models in a position parallel with their axes. Each collection is accompanied by a catalogue containing, besides the name of the model, its form and its crystallographic symbol according to Naumann's system; and, in addition to these, the most important minerals and chemical compounds which the models represent.

3498. Eighteen large **Diagrams of Crystals.**
Prof. G. vom Rath, Bonn.

These diagrams are manuscript drawings, and are used for the illustration of mineralogical and crystallographical lectures.

3499. Models of Crystals, made from glass plates.
W. Apel, Göttingen.

The large size of the models renders them especially useful for demonstration teaching. The angles agree with those of the natural crystals, as exactly as the difficulty of manufacture will permit. The threads showing the axes have the same colour for similar axes, and a different colour for dissimilar axes. In the hemihedral forms the corresponding holohedral forms are included, and from the colours marked on them it can be seen whether they have disappeared or remain in the hemihedral forms. The hexagonal system is, according to Miller, referred to the three axes cutting each other at oblique but equal angles.

3500. Models of Crystals, in wood and wire.
Royal Mining Academy, Freiberg, Saxony.

3501. Tables for Instruction in Crystallography.
Dr. F. Pfaff & Th. Bläsing's Library, Erlangen.

3503. Forms of the Isometric Systems, represented in all possible combinations. *Prof. Dr. Prestel, Emdem, Hanover.*

3504. Skeleton of a Rhombohedron, with a divided side for crystallographic demonstration. *Albrecht, Tübingen.*

By the string placed round the dividing rods all the faces of the rhombohedral system, of which the indices of *h*, *k*, & *l* are represented by three of the number 0 to 5, can be illustrated. Compare Miller's Treatise on Crystallography, p. 55.

3505. Book, "Nephrit und Jadeit nach ihren mineralogischen Eigenschaften sowie nach ihrer urgeschichtlichen und ethnographischen Bedeutung." By Heinrich Fischer, Stuttgart, 1875. With 131 woodcuts, and two chromolithographs.
Prof. Leopold Heinrich Fischer, Freiburg, Baden.

In this book is originated a new branch of mineralogy, viz., the archæological and ethnographical. Hitherto the sculptures, amulets, and ornaments of stone in the museums have been looked upon as show objects, but as quite devoid of scientific interest.

In this book these studies are carried out as the material of numerous objects in these museums obtained both in and out of Germany, especially with regard to Nephrite and Jadeite, which play such an important part among the archæological minerals, and also with regard to the rest of the important minerals of this class.

The volume also serves as a guide to the series of imitations (in wax, gypsum, &c.) exhibited by Dr. Adolf Ziegler, of Freiburg, in Baden, of such scientifically important and prominent original sculptures from Asia, New Zealand, Marquesas Island, Otaheite, Central America, Mexico, Peru, &c. as are partly exhibited in the Freiburg Mineralogical Museum and the Freiburg Ethnographical Museum, and partly were lent by other museums to the Freiburg Museum for the preparation of imitations.

There can be no doubt that the presence of such imitations in the Archæological and Ethnographical Museums will be a great help to this branch of study, which has until now been quite neglected, but which promises to become of the highest importance for the study of the most ancient races of men; for the stone remains are indestructible proof of departed periods of civilisation.

The remains of sculpture, the archæological records of America and Oceania, so remarkable in their form and in the astonishing hardness of the minerals out of which they are made, and which have hitherto been neglected in Europe, will by means of these models become better known.

3506. A number of **Imitations** of large and small **Amulets, Idols, Implements,** &c. of archæological and ethnological importance. Compare the work of Professor H. Fischer, "Nephrit und Jadeit." *Dr. Adolph Ziegler, Freiburg, Baden.*

These imitations (of different materials according to the characters of the imitated minerals) were prepared, on the suggestion of Prof. H. Fischer, Director of the Ethnographical Museum of the University of Freiburg, and were used partly to preserve for the ethnographical collection of the University copies of the originals sent to Freiburg for exhibition, and partly for purposes of exchange. Professor Fischer says, in his new work on Nephrite and Jade, "I had in Freiburg, in Baden, the much desired opportunity for the manu- "facture of casts, as Dr. Ziegler, whose preparations in wax are deservedly "valued in the studies of anatomy and t history of evolution, has succeeded "so happily in the imitation in w ie originals which I handed to him, "even to the extent of copying the l colours so exactly that it is difficult "to say, on looking at the two to , which is the original and which "the imitation."

A list of the different pieces is given w the imitations, containing references to Professor Fischer's work.

3507. Sohncke's Universal Model of the Raumgitter, made by Heckmann of Carlsruhe, explaining the theory of the structure of crystals.

Appendages to the model :—

A key.

12 elastic spiral threads.

6 tin caps. *Prof. Sohncke, Carlsruhe.*

3508. Model of Octahedral "Raumgitter."

Prof. Sohncke, Carlsruhe.

The universal model of the raumgitter has the object of bringing to view the 14 possible different kinds of Raumgitter or point systems of the parallelepiped form.

Its importance consists in the following points :—

(1.) According to Bravais the molecules of all crystals are arranged in a Raumgitter

(2.) According to a theory of crystal structure, developed a short time ago by the exhibitor, the molecules are arranged according to regular systems of points, which latter are always composed of many Raumgitters placed in each other.

From this one model all raumgitters can be derived; it is made so as to be movable. The dimensions can be altered by drawing out eight edges, after the manner of a telescope Also, the globe must be divided in similar proportion to the edges

For the purpose of altering the angles, each angle is provided with two joints, by means of one of which it is possible to incline the four unlengthenable edges, which are now vertical. The four horizontal edges must previously be placed parallel to each other

Elastic threads are sent which can be stretched between different globes to show their lines of combination. The tin caps are used for indicating particular spheres.

The fixed model shows the octahedral Raumgitter; of course the movable model can be brought to this form.

3509. Case, containing **15 Models of the most important Diamonds,** made with Bohemian crystal glass.

Dr. Th. Schuchardt, Görlitz.

SECTION XVIII.—BIOLOGY.

SOUTH GALLERY, UPPER FLOOR, ROOM (N).

I.—MICROSCOPES AND ACCESSORY APPARATUS.

(a.) MICROSCOPES OF HISTORICAL INTEREST.

3510. Compound Microscope, invented and constructed about 1590 by Zacharias Janssen, spectacle-maker, at Middleburgh, Netherlands.

The Scientific Society of Zeeland, at Middleburgh.

3511. Two Microscopes, by Jan van Musschenbroek, a Dutch mechanician (b. 1687, d. 1748).

Professor Dr. P. L. Rijke, Leyden.

3512. Microscope, of silver, **used by Anthony van Leeuwenhoek,** the Dutch Philosopher (b. 1632. d. 1723), in his investigations, and probably constructed by him.

Professor Dr. J. A. Boogard, Director of the Anatomical Museum, Academy of Leyden.

3513. Wilson's Pocket Microscope, with three single powers, about $\frac{1}{4}$, $\frac{1}{6}$, and $\frac{1}{8}$ inch, and box of objects of an early period. *William Sykes Ward.*

3514. Pocket Microscope, for opaque objects, four powers in Lieberkuhns 1 in., $\frac{1}{2}$ in., $\frac{1}{4}$ in., and $\frac{1}{8}$ in. *William Sykes Ward.*

3515. Achromatic Microscope, by Oberhäuser, of Paris, with powers of an early period; fine adjustment, achromatic condenser, and a curious double movement stage.

William Sykes Ward.

3516. Compound Microscope, by Dollond, formerly belonging to Josiah Wedgwood, potter. It is not inclinable; provided with two movements; the stage is rude in mechanism. There are six object-glasses, frog-plate, and other appliances.

Robert Garner, F.R.C.S.

3517. Grand Microscope, with solar reflector and appliances. Made by Benjamin Martin about 1740.

The Committee, Royal Museum, Peel Park, Salford.

The details of this extraordinary microscope are described in full in a paper by Mr. J. B. Dancer, F.R.A S., affixed to the instrument.

3526. An Achromatic Microscope, made in 1807 by Hermann van Deyl, in Holland, the first maker of true achromatic objective lenses for microscopes.

Professor Buys-Ballot, Utrecht, Holland.

(See Harting, Das Mikroskop, iii., page 132, sqq., where this very microscope is described.)

3526a. Microscope of Nobili.

Royal Institute of "Studii Superiori" at Florence.

3527. An old Microscope, 1705, made by J. Marshall in London, with seven objectives, objective table, object stand of ebony wood, ivory plates, two pincettes, needle, and leaden channel. Property of His Highness Prince Pless, Castle Fürstenstein. *Prof. Polck, Committee of Breslau.*

3528. Microscope, by Musschenbook, in leather case.

Royal Museum at Cassel (Director, Dr. Pinder).

The microscopes exhibited are the oldest in the collection of the Cassel Museum.

The microscope of Jan van Musschenbroek dates from the 17th century. It has been frequently described and represented in drawings. The University of Leyden possesses a similar one. This specimen was seen in 1809 by *Uffenbach* in the collection of Professor *Wolfarth* in Cassel.

3529. Two Microscopes, by Leutmann, in leather case.

Royal Museum at Cassel (Director, Dr. Pinder).

These are microscopes by (or after) *Leutmann*, as is shown by the drawing in *Wolff's* "Allerhand Nützliche Versuche," III. Bd., p. 291. *Harting* gives no drawing of these microscopes.

3530. Microscope, by Hartsoeker, in leather case.

Royal Museum at Cassel (Director, Dr. Pinder).

A microscope by *Hartsoeker*, invented before 1694. *Wolff*, who gives a description and drawing of it, makes no mention of *Hartsoeker* as being its inventor, but gives the description to that of *Musschenbroek's* instrument. It was found by *Uffenbach* in Professor *Wolfarth's* collection.

3529a. Large Amici Microscope, with apparatus complete, by Chevalier. *The Royal Microscopical Society.*

3529b. Double Microscope, by Culpepper.

The Royal Microscopical Society.

3529c. Single Microscope, by Dolland.

The Royal Microscopical Society.

3529d. Mechanical Finger, for picking up minute objects, by Bailey, after Professor Smith's pattern.

The Royal Microscopical Society.

3529e. Double Microscope, by Marshall.

The Royal Microscopical Society.

for different adjustments are well contrived, and the workmanship of considerable merit. Had not achromatic objectives been constructed, the reflecting engiscope would probably have maintained its ground.

3531c. Goring's Operative Aplanic-Engiscope, described and figured in Pritchard's "Microscopic Illustrations," 1830. An early form of compound microscope mounted with ball and socket universal joint, oval plane mirror and 2 in. condenser beneath the stage, black box for opaque objects, forceps, &c.

3531d. Slit and Prisms used in the first form of Spectrum Microscope. *H. C. Sorby.*

As shown by the woodcut exhibited, the slit was placed some distance from the microscope, and the prism fixed below the achromatic condenser, so that an image of the spectrum was seen on the object examined under the microscope, and the relative powers of absorption for different rays observed. This form of apparatus has been entirely abandoned for many years, and replaced by the exhibitor's direct vision spectrum eye-piece, exhibited by Mr. John Browning, and by the exhibitor's binocular spectrum apparatus, exhibited by Messrs. R. & J. Beck.

This apparatus is described in the exhibitor's paper in the "Quarterly Journal of Science," 1865, vol. ii., p. 198.

(*b*.) Microscopes by Modern Makers.

3532. Microscope; the first made on Joseph Jackson Lister's model, by James Smith, in 1839, but refused by the trade as being too great a departure from the old and approved model. *Joseph Beck.*

3532a. Microscope with Large Compound Stand. Designed by Andrew Ross about 1832. With rotating stage and sub-stage added in 1851. $\frac{1}{12}$ inch objective of old form attached. *Ross & Co.*

3532b. Microscope with Large Compound Stand on the Jackson slide principle. Designed by F. H. Wenham in 1873. With $\frac{1}{8}$ inch new patent objective attached. *Ross & Co.*

3532c. Microscope with Portable Folding Stand for travellers. Designed by F. H. Wenham in 1874. With 1 inch triple objective attached. *Ross & Co.*

3532d. Microscope with Portable Stand, with objective suitable for students. *Ross & Co.*

3533. Microscope, on the approved Jackson model, with a limb continued under the stage and planed out in one continuous groove to insure perfect concentricity of the optical and illuminating apparatus. Designed for and exhibited in the Great Exhibition of 1851. *R. & J. Beck.*

3533a. Microscope Stand, with modification of Jackson's limb, Wenham's binocular body, a concentric rotating stage, and Brown's iris diaphragm. *R. & J. Beck.*

3534. "The Educational Microscope." The first cheap microscope supplied with English object glasses. Prepared for and exhibited in the Paris Exhibition of 1855 by Smith, Beck, and Beck. *J. Beck.*

3535. "Universal Microscope." This instrument, made for the Exhibition of 1862, showed a new method of varying the object glasses and eye-pieces without removing them, the mode of constructing a simple binocular body, and a loose lever as a slow motion. *R. & J. Beck.*

3536. "The Popular Microscope." The first cheap binocular microscope brought out in this country, in 1864. *R. & J. Beck.*

3537. "The Economic Microscope;" a working instrument when the binocular arrangement is not required. *R. & J. Beck.*

3538. "Darwin's Dissecting Single Microscope." *R. & J. Beck.*

3538a. Sorby's Binocular Spectrum Microscope, with his new apparatus for measuring the wave length of every part of the spectrum. *R. & J. Beck.*

3539. "Beck's Dissecting Single Microscope." *R. & J. Beck.*

3540. Stephenson's Erecting Binocular Microscope. *J. W. Stephenson.*

The primary objects of this microscope are, as the name implies, the erection of the image and the utilization of deep powers by the binocular. The binocular effect is produced by the use of two equilateral prisms, placed together at an angle of 4° 30′; the two edges in contact form a wedge by which the cone of light from the objective is divided, and, after internal total reflection, is laterally inverted. The divided pencil of light is then received on a plate of silvered glass at the polarizing angle, the reflection from which completes the erection of the image. This plate, which is of black glass, rotates on its axis, the black side being instantly exchanged for the silvered side, when an analyzer is required.

The advantages of this instrument are,—

1. The erection of the image.
2. The small angle (9°) at which the bodies converge, giving a convergence towards an imaginary point at a distance of 14 to 15 inches from the eye.
3. A horizontal stage, with the bodies inclined at a convenient angle.
4. The immediate substitution of an analyzing plate of black glass when polarized light is used.

5. Identity of illumination in each tube.
6. The use of the highest powers by the projection of the prisms beyond the body of the instrument into the objective.

3540a. New Binocular Microscope. *Henry Crouch.*

This instrument has a concentric rotating stage provided with adjustments for centering to the highest powers that can be applied. The sub-stage is also of new construction, being detached from the stand by means of a horizontal slide, and leaving the space underneath the stage entirely clear for greater convenience in the use of ordinary oblique illumination.

3540b. Newly arranged Binocular Microscope. *Henry Crouch.*

This is of somewhat similar construction to the above, but not so expensively finished; with and without sub-stage.

3540c. New Educational Microscopes for Botanical and Histological Work. *Henry Crouch.*

3540e. Students' (Monocular) Microscopes of Old and New Pattern. *Henry Crouch.*

3541. Student's Microscope. *James How & Co., London.*

3542. Popular Binocular Microscope. *James How & Co., London.*

3542a. Microscope Lamp. *James How & Co., London.*

3542b. Tate's Air Pump. *James How & Co., London.*

3542c. Selection of Transparent Photographs, for the **Lantern,** illustrating lectures upon geology, consisting of sections of strata, groups of fossils characteristic of the various sedementary formations, restorations of extinct animals, &c. *James How & Co., London.*

3543. "Educational Microscope." With two object glasses, two eye-pieces, condenser, &c., in mahogany box. Suitable for biological, histological, and physiological research. *M. Pillischer.*

3544. "Student's" or "Educational Microscope." With three object glasses, three eye-pieces, condenser, polarising apparatus, animalcule cage, stage-forceps, &c., in mahogany case. Suitable for clinical and biological research, &c. *M. Pillischer.*

3545. "New College Microscope." *James Swift.*

In this microscope the optical tube slides through a fitting lined with velvet for smoothness of action. The fine adjustment has direct central movement, and is so constructed as not to be deranged by constant use. The diaphragm is flush with the surface of the stage, thus leaving the tube-fitting free underneath for the use of apparatus, and, if required, a diaphragm can be used in conjunction with any of the stage accessories.

3546. "University Student's Microscope," in a cheap and efficient form, especially designed for medical and botanical students. *James Swift.*

3547. Crane Arm Binocular Microscope, with newly contrived concentric stage and adjustable object holder moving upon glass bearings. *James Swift.*

3548. Student's Microscope in an alloy of German silver and aluminium. *James Swift.*

3549. Microscope. *Crisp, London.*

3550. Microscopes. *G. S. Wood, Liverpool.*

3551. Microscope with complex adjustments, searcher, and oblique condenser apparatus. *Dr. Royston-Pigott, F.R.S.*

This microscope is fitted with a pec[illegible] hypocycloidal movement and traversing screws for very delicate obser[illegible]s. The condenser possesses wide rectangular movements combined with a [illegible]ique oscillating oblique action for directing the minute image of a flame or the sun either directly or obliquely upon any desired point in the field of view, giving fine views of many difficult objects, and gorgeous diffraction phenomena with circular solar spectra. It is also fitted with Dr. Royston-Pigott's searcher for aplanatic images, by which much greater depth of focus is attained, and new powers of correcting chromatic and spherical aberration, by moving the searcher between the objective and the eye piece or ocular.

3552. Improved Microscope, with rotating body. *John Browning.*

This instrument is contrived so as to combine the advantages of the English with the continental models; it is especially adapted for dissecting purposes, as the body rotates with the stage; objects may be examined with any power without losing their centricity.

3553. Stephenson's Binocular Microscope. *John Browning.*

In this instrument, for the first time, the planes introduced by Mr. Stephenson for altering the direction of the ray, so that the microscope can be used with the stage in a horizontal position, have been introduced near the eye-pieces in the separate bodies; this arrangement will, it is believed, be found to possess considerable advantages. With Stephenson's binocular, objects may be examined with both eyes with the highest objectives.

3554. Microscope with Micro-Spectroscope. *John Browning.*

The micro-spectroscope is intended for the observation of absorption bands in the spectra of solids or fluids, either by reflected or transmitted light. The instrument exhibited contains Mr. Sorby's most recent improvements.

3555. Pocket or Field Microscope, with two achromatic object glasses, contained in a leather case, measuring $7 \times 3 \times 1\frac{3}{4}$ in. *John Browning.*

3556. New Portable Microscope. *John Browning.*

This powerful and complete instrument, fitted with a sub-stage, accessory apparatus, polariscope, &c., is contrived to fold on a hinged joint in such a manner that when set up it is the size of an ordinary microscope, but when closed, it packs in a case of which the outside measurement is 6 × 6 × 9.

3557. Microscope Stand with Chain Movements, exhibited in 1851.

Educational microscope. Plain stage, with dividing English object glass 2-inch, 1-inch, ½-inch. In cabinet.

The same with mechanical stage, with 1-inch 15°, and ¼-inch 70°., English objectives; in cabinet.

Dissecting microscope, 3 powers.

Dissecting microscope, with glass stage and mirror, 3 powers.

Pocket microscope, for collecting diatomaceæ, &c.

Pocket microscopes, for botany, entomology, &c.

William Ladd & Co.

3557a. Polarizing Microscope, large Des Cloiseaux pattern, capable of being placed either horizontally or vertically by means of a joint and clamp, with all requisite accessories for the complete study of the optical bi-refracting properties of natural or artificial crystals, such as a goniometer for measuring the distance between optical axes in air or in oil, at various temperatures; ice-pan for oil; copper stove with thermometers and spirit lamps; the microscope frame and Nicol polarising prism, both being movable by means of a rack and pinion. *M. A. Picort, Paris.*

3557b. Polarizing Microscope, large pattern, with all requisite accessories, the body of the microscope alone being movable on the stand. *M. A. Picort, Paris.*

3557c. Polarizing Microscope, small pattern, mounted vertically with a small goniometer for measuring the distance between axes in air. *M. A. Picort, Paris.*

3558. Microscope (Small Model), with a Cylindrical Clip for Objectives.

Geneva Association for Constructing Scientific Instruments.

This model of a microscope is at once strong and simple. The system of the cylindrical clip is as follows:—

The objective is not screwed upon the tube, but it is only pressed by a spring against a carefully turned bearer. To take up the objective, it is sufficient to draw it away transversely after having lowered it so as to exert a pressure in the direction of the axis. The objective is more easily placed in position than removed. The advantages resulting from this arrangement are:

1. A great saving of time to the observer, the magnifying changes by the objective being feasible instantaneously.
2. The mechanical centering of the whole objective is better than that usually obtained with the screw.

3559. Large Microscope, suitable for any research, with rotating stage, and joint for inclining the body of the microscope.
R. Wasserlein, Berlin.

3560. Small Student's Microscope.
R. Wasserlein, Berlin.

3561. Microscope No. 1, combined with a photographic apparatus and accessories. *Seibert & Krafft, Wetzlar.*

This apparatus can be connected with every simple microscope, which, for this purpose, is placed perpendicularly under the box in front of the apparatus, after which, in order to exclude unsuitable light, the cloth-bag, fitting tightly by means of a gutta percha ring, is pulled over the tube. The adjustment of the picture is effected by means of the glass-plate contained in the box, which is provided with squares and the ocular-like microscope. The lines of the glass-plate must be placed downwards. The microscope is placed on the glass plate, and regulated by the upper lens in such a manner that the lines can be seen plainly; thereupon the picture is inserted, the microscope being used as ocular. In this manner the picture is sure to lie exactly on the lower surface of the glass-plate; consequently also on the prepared plate to be inserted afterwards. By applying the illuminating apparatus the plane-mirror of the microscope should be used, the arrangement of which is easily understood. The achromatic condenser, accompanying the apparatus, consists of three achromatic lenses, and fits in microscope No. 3 in the Exhibition.

3562. Microscope No. 3. *Seibert & Krafft, Wetzlar.*

3563. Microscope No. 5. *Seibert & Krafft, Wetzlar.*

3564. Microscope No. 7. *Seibert & Krafft, Wetzlar.*

3565. Complete Microscope, with Abbé's illuminating apparatus, magnifies from 20 to 1100 diameters.
F. Schmidt and Haensch, Berlin.

3566. Microscope (specially adapted for mineralogical research), with polarisation apparatus. *Ernst Leitz, Wetzlar.*

Height of the instrument, 1 foot 3 inches.

There is an arrangement for turning the tube round the optical axis, together with the upper round stage, which is prepared (after the design and drawing of Professor Mohl of Cassel) with a graduated rim.

The under stage carries the vernier, and is provided with a circular diaphragm, which, together with the polariser, is furnished with a convex lens.

The coarse adjustment is done by a rack and pinion, and the fine adjustment by a micrometer screw; with draw-tube, and plane and concave mirror with vertical and horizontal movement. An eye-piece micrometer, the cross lines of which can be easily used for estimating the angle of dichroism, and angle measurement, by holding the eye-piece fast and turning the stage on which the object lies. A revolving fitting for holding five objectives. Analyser for fixing to the eye-piece, with a graduated circle.

A calcspar plate placed between the eye-piece and the analyser serves for the stauroscopic examination of crystals; magnifying powers 60 to 2,800 diameter.

3567. Microscope, with nine objectives and four eye-pieces and other apparatus. *E. Leitz, Wetzlar.*

3568. Microscope, with three eye-pieces and four objectives. *E. Leitz, Wetzlar.*

3569. Microscope, with two eye-pieces and four objectives. *E. Leitz, Wetzlar.*

3570. Microscope, with two eye-pieces and three objectives. *E. Leitz, Wetzlar.*

3571. Microscope, with two eye-pieces and three objectives. *E. Leitz, Wetzlar.*

3572. Microscope, with one eye-piece and two objectives. *E. Leitz, Wetzlar.*

These instruments are exhibited as specimens of accurate and elegant work, combining solidity and cheapness.

3572a. Microscope, large model, with arrangement for the study of rocks. *A. Nachet, Paris.*

3572b. Microscope, with camera obscura, for photographing microscopic objects, arrangement of M. Aimé Girard. *A. Nachet, Paris.*

3572c. Microscope for demonstration, which can be passed from hand to hand in histological lectures. *A. Nachet, Paris.*

3572d. Portable Microscope. *A. Nachet, Paris.*

3572e. Binocular Microscope, producing at will the effects of the stereoscope and the pseudoscope. *A. Nachet, Paris.*

3572f. Microscope for the study of the cornea and of the pupil. *A. Nachet, Paris.*

3572ff. Natchet's first form of Binocular Microscope. *F. Crisp, Notting Hill.*

3572g. Natchet's latest form of Binocular Microscope (both stereoscopic and pseudoscopic). *F. Crisp, Notting Hill.*

3572h. Stevenson's Binocular Microscope, by Ross, for high powers. *F. Crisp, Notting Hill.*

3572i. Ahrens' Binocular Microscope, with double similar prisms. *F. Crisp, Notting Hill.*

3572j. Ahren's Binocular Microscope, with prism of Iceland Spar (using the ordinary and extraordinary images). *F. Crisp, Notting Hill.*

3572k. Holmes' divided Object Glass Binocular Microscope (the object glass being cut in halves and each half forming one of the images). *F. Crisp, Notting Hill.*

3572l. Tolles' Binocular Eye-piece.
F. Crisp, Notting Hill.

3572m. Beck's Binocular Simple Microscope.
F. Crisp, Notting Hill.

3572n. Nachet's Triocular Microscope.
F. Crisp, Notting Hill.

3572o. Nachet's "Grand Microscope renversé avec miroir argenté" (giving very large magnification from the long distance from object glass to ocular). *F. Crisp, Notting Hill.*

3572p. Chevalier's Universal Microscope.
F. Crisp, Notting Hill.

3572q. Beale's Demonstrating Microscope.
F. Crisp, Notting Hill.

3572r. Brown's Pocket Microscope.
F. Crisp, Notting Hill.

3573. Microscope for Demonstration.
Prof. Recklinghausen, Strassburg.

The instrument is so made that it can be taken up in the hand like a telescope, placed against the window, and the light found by even an unpractised observer in a very short time. By using a condensing lens with the instrument, ample illumination is obtained; but faint daylight and even lamplight will suffice. The instrument can be quite conveniently used with a magnifying power of 400 diameters, especially as an arrangement (as in Hartnack's immersion systems) is fitted to the lower end of the tube and affords the most accurate adjustment.

The object is to demonstrate microscopic preparations to a large audience. This demonstration-microscope has this advantage over ordinary microscopes for demonstrations, that it can be passed quickly round a class. As the microscopic object under observation has to be vertical, it follows that the preparation must be mounted and the cover glass fixed, and moreover it must not float in a liquid.

The tube with adjustment stand is made by Hartnack and Pratzmowski, the apparatus for illumination and the table by Majer of Strassburg.

3574. Microscope, with a set of objectives and eye-pieces, containing—

a.	Objective,	No. 5,	magnifies	184	to	506	times.
b.	,,	No. 6,	,,	220	,,	612	,,
c.	,,	No. 8,	,,	366	,,	1,012	,,
d.	,,	No. 9,	,,	458	,,	1,266	,,

R. Winkel, Göttingen.

3575. Microscope constructed specially for the examination of microscopic sections. *R. Fuess, Berlin.*

3576. Immersion Lens, with special contrivance for increasing the magnifying power from 300 to 1,000 times with the low eye-piece. *R. Winkel, Göttingen.*

3577. Microscope (small model), commonly used. *Dr. Hartnack, Potsdam.*

3578. Small Microscope, specially suited for mineralogical researches. *Dr. Hartnack, Potsdam.*

3579. Large Microscope. *Dr. Hartnack, Potsdam.*

These instruments are sufficiently well known, and it is not necessary to bring forward their peculiarities, but the mineralogical microscope has been recently constructed, and the exhibitor requests mineralogists to direct their attention to it.

3579a. New Dissecting Microscope with three achromatic powers, support for arms, and rack focussing giving three movements. *Harvey, Reynolds, and Co.*

3580. Microscope for Dissecting, with pincers and plate for dissection, and simple Microscope with rod action. *Geneva Association for Constructing Scientific Instruments.*

The Geneva Association constructs three different models of microscopes. In the plainest model the focussing movement is worked direct by the hand acting upon a rod which supports the optical system, and which slides up and down through a groove. The light is given by a mirror placed below the stage. The instrument is enclosed in a box. In the second model the focussing is effected by means of a rack. Lastly, in the third model, the most complete of all, a pair of pincers revolving around two rectangular supports are substituted for the plate. With the help of this addition an object placed at the extremity of the pincers can be successively examined on all sides, and without leaving the focus of the glass. The sighting is the same as in the preceding model.

The optical system of each of these microscopes is composed of three "Wollaston" doublets with inner diaphragms, of 1 inch, ½ inch, and ¼ inch focal distance, giving magnifying powers of 9, 18, and 36 times, for 25 cm. length of vision.

The Geneva Association supplies besides to those who require higher powers achromatic lenses with short focus, giving great clearness and light. An achromatic lens of 2 millimetre focus produces a magnifying power of 125 times with perfect clearness.

3581. Large Microscope, with Reversing Action, and cylindrical pincers for objectives. *Geneva Association for Constructing Scientific Instruments.*

This instrument, of which the general construction is that of Ross's English microscopes, is remarkable for the following arrangements:—It may be used in three different positions, vertical, horizontal, or oblique, and is specially applicable to the photography of microscopic objects. The illumination is effected by means of a mirror carried by a system of jointed rods, which limits its movement to an arc, the centre of which is the object to be observed. The best illumination is thus quickly procured, the observer not having to regulate at the same time the focal distance of the mirror and its lateral distance from the axis of the microscope. The condenser is moved by the help of a crank, which serves to regulate exactly the position of the diaphragm. The whole condensing system, turning around an eccentric axis, can be very rapidly modified.

The stage turns independently of the tube. The focussing is effected, for coarse adjustment, by means of a crank, and for fine adjustment by means of a milled screw acting upon the tube supporting the objective, by the intervention of a lever that lessens the amplitude of the movement.

The tube supporting the objective is carried by a spring which serves to prevent the objects being crushed, when by mishap the objective is lowered too quickly. The milled screw for focussing is used as well for the micrometrical measurement of objects under observation, as for regulating the chemical force in the use of the objective in photography.

The objective is not screwed on to the tube, it is only pressed by spring pincers against a steel bearing adjusted with the greatest care. To take off the objective, it is sufficient to draw it away transversely by pressing in the direction of the tube of the microscope. The objective is fixed as instantaneously as it is removed. The advantages resulting from these arrangements are the following:—1st. A great saving of time to the observer. 2nd. A mechanical centring of the whole objective much more perfect than that obtained by a screw. The defects of centring being immediately discovered may be partly corrected. 3rd. There is the easy choice of the side of the objective that gives the best effect when the oblique illumination is employed.

3582. Microscope, with durable body, with rotating movement round its axis, fine adjustment by means of steel prism, condenser, polarizing apparatus, magnifies from 10 to 1,200 diameters. *W. Teschner (successor to Amuel), Berlin.*

3583. Microscope, with magnifying power from 20 to 1,000. *W. Teschner, Berlin.*

3586. Polarizing Microscope, for showing rings in double-refracting crystals. *Dr. Stone.*

3587. Polarizing Microscope, with movable body and prism. *M. A. Picort, Paris.*

3588. Polarizing Microscope, with movable body. *M. A. Picort, Paris.*

3589. Picort Vertical Polarizing Microscope. *M. A. Picort, Paris.*

3589a. Polarizing Microscope, with lens for parallel light, and Nicol prisms for measuring the axes. *Laurent, Paris.*

3590. Solar Microscope. *Laurent.*

3590a. Dr. Lionel Beale's Portable Microscope. *Thomas. Hawksley.*

(*c.*) ACCESSORY APPARATUS.

3592. Microscopic Apparatus. Series of the more important pieces of apparatus and object glasses now supplied for use with the microscope. *R. & J. Beck.*

3593. Object Glasses (4), showing the lenses before they are put into the cells. *R. & J. Beck.*

3593a. New Stand on the Continental Model, the diaphragm being provided with centering screws so that it can be adjusted to each objective as applied. *Henry Crouch:*

3593b. Microscope Objectives and accessory Apparatus. *Hen·y Crouch.*

Suited to the stand described above, and for microscopic work generally, and mounting apparatus and materials.

3594. Object Glasses, Apparatus, and Accessories used in the different branches of microscopical research. *M. Pillischer.*

3595. Microscope Lamp. *M. Pillischer.*

3595a. Fittings for Microscope. *M. Lutz, Paris.*

3596. Apparatus to be used with the Microscope, for securing perfectly central illumination, manufactured by Wood of Liverpool. *Rev. W. H. Dallinger, F.R.M.S.*

The object of the apparatus is to secure minute and delicate alterations in the position of the flame-image upon the mirror or prism, since it has been found by the exhibitor that perfectly central illumination can only be secured by having the image of the flame exactly under the optical axis of the sub-stage combination, after the latter has been made to coincide with the optical axis of the object glass. This will enable the microscopist to illuminate the whole field of a $\frac{1}{4}$-inch object glass through an aperture of $\frac{1}{100}$th of an inch in diameter. But it can only practically be done by a fine set of mechanical motions in rectangular positions giving perfect command of the position of the flame.

3597. Apparatus for Continuous Observation of Minute Organisms with the highest powers, by preventing evaporation of the fluid in which the organisms live. *Rev. W. H. Dallinger and J. J. Drysdale, M.D.*

This apparatus was devised by Messrs. Dallinger and Drysdale for prosecuting their "Researches into the Life-History of the Monads." It is used upon the ordinary "mechanical stage" of the microscope, so as to admit of the continuous examination under the highest powers of the same drop of

Small air pump for mounting.
Lamp for microscope, with white cloud reflector.
Bottles and dipping tubes for collecting materials.
Collecting bottle, net, hook, and jointed rod.
Cements, varnish, liquids, and media for mounting.
Boxes, cases, cabinets, for finished objects.

Edmund Wheeler.

3606a. Micrographic Study of Paper Manufacture.
M. Aimé Girard, Paris.

3607. Instrument for verifying Micrometers of Microscopes.
W. F. R. Suringar, Leyden.

Consists of a metallic frame, reposing at each side upon four pillars fixed in a wooden bottom, through which are thrust three screws, two at the one side, one at the other side, for regulating the horizontal position of the instrument. Upon the frame slides another, the quick movement of which is regulated by a rack and pinion, and upon this a third, destined for bearing the scale, with slow motion, directed by an adjusting screw with milled head. For using the instrument, put the scale, divided into a certain number (fig. 35) of millimeters on the inner slide, or (in the case of microscopes with very small stage, such as the small Oberhäuser-microscope now shown), on the three extra supports on the outer side, regulate the screws of the small additional table destined for bearing the microscope, in such a manner that the stage of the microscope glides under the frame, and the divisions of the scale can be centered with the field of the microscope. After having adjusted the ends of the eye-piece micrometer in the microscope to the ends of the stage micrometer that is to be verified, seen through the microscope, place the microscope over the middle part of the instrument, move the scale till the first division of the scale can be seen in the field of the microscope, adjust and measure the first division, and subsequently all the others, taking care to measure always from the same side (*e.g.* the left) of the lines. Notice the number of entire divisions of the eye-piece micrometer, and tax the tenth part of them, to which each division of the scale corresponds. After having measured them all, one by one, make the addition, and divide the amount by the number of divisions measured. The quotient indicates the mean value of each division of the scale expressed in parts of the eye-piece micrometer, viz., of the millimetre of the stage micrometer. This quotient, divided into one, expresses the exact value of the millimetre to be verified in parts of the scale used for comparison, and itself previously compared with a standard scale. The accuracy obtained is proportional to the square root of the number of divisions compared one by one, and makes sure easily of the $\frac{1}{1000}$ part of a millimetre.

The instrument should be placed before a window, and at a distance not exceeding six feet from it, because otherwise the scale would not receive sufficient light for seeing the divisions clearly through the microscope.

A description of verifications made by the instrument, with cut, accompanies it.

3608. Apparatus for Microscopical Research in the open air. *Prof. Dr. Leonard Roesler, Klosterneuburg.*

3609. Re-agents for Microchemical Researches, in box.
Prof. Dr. Leonard Roesler, Klosterneuburg.

3610. Instruments for Microscopical Researches, in box. *Prof. Dr. Leonard Roesler, Klosterneuburg.*

3611. Instruments for Microscopical Researches on living organisms, adapted to their observation when under the influence of various gases and at different temperatures. In box. *Prof. Dr. Leonard Roesler, Klosterneuburg.*

3612. Drawings illustrating preceding Apparatus. *Prof. Dr. Leonard Roesler, Klosterneuburg.*

3613. Freezing Apparatus. A simple form for preparing soft tissues for microscopical examination, consisting of a solid copper cylinder with wooden handle and felt cap to fit over cylinder. *Dr. Urban Pritchard.*

Mode of use:—Immerse cylinder in mixture of ice and salt for a few minutes; then remove and wipe, place tissue, to be cut, after being moistened with gum, on metallic end. Put felt cap over cylinder; tissue will be frozen and ready for cutting in two or three minutes.

3614. Glass Microtome for microscopical sections of hardened or frozen tissues. *Dr. M. E. Mulder, Groningen.*

The hardened tissue, previously imbedded in a cylindrical mass of wax, consisting of a mixture of Stearine - - - 30
Hogs lard - - - 24
White wax - - - 16
is introduced into the glass tube of the microtome, which is polished at its upper margin.

Any rotation or movement of the wax cylinder, which is exactly of the same size as the tube, is prevented by the four pins. The wax cylinder can be moved up or down by means of a screw, and sections are made by passing a knife over the polished surface of the tube.

The thickness of the sections is indicated by the lines on the screw. (Every line is $\frac{1}{50}$ mm.)

When the microtome is used for freezing, the glass tube is unscrewed and replaced by the freezing box. The tissue, imbedded in a solution of gum arabic, is frozen by filling the freezing-box with snow or ice and salt.

3615. Kratometer for finding magnifying power and focal length of objectives. *Dr. Royston Pigott, F.R.S.*

This simple instrument is so contrived that whatever object glass is used, the actual power is ascertained at once, whatever be the length of body employed. A stage micrometer of lines ruled to 100ths and 1,000ths of an inch is viewed by the kratometer eye-piece, and the number of divisions of the stage micrometer embraced by ten of the kratometer, gives exactly the magnifying power, if multiplied by ten. This instrument at once determines the focal length and comparative powers of all object-glasses submitted to this test.

3616. Microscopic Refractometer for ascertaining the mean refractive index of plates of glass or lenses. *Dr. Royston-Pigott, F.R.S.*

A new refractometer for determining the refractive index of white light (or mean rays or line E in the solar spectrum) of small plates or lenses of

refracting material. The instrument measures to the 100,000th of an inch, the thickness of a thin plate as covering glass ·004″ thick, and the distance which an image is refracted upwards.

A minute prism reflects the light through a small plano-convex lens fixed at the end of the measuring screw; the prism is illuminated by solar or artificial light by a condenser, and reflected up the axis of the microscope. Differential toothed wheels measure the number of revolutions of the screw (nearly 100 threads to the inch), and indicators give the 100ths, 1,000ths, 10,000ths, and 100,000ths of an inch. The instrument detected 32 changes of colour in Newton's rings of contact between the central black spot in air, caused by a film half a millionth of an inch thick, and the last vanishing colour on separating the plano-convex lens from a plane surface with which it had been in contact. It has measured the refractive index to three places of decimals in thin flint glass 0″·0042 thick.

3616a. Sorby's Standard Interference Scale, for measuring the position of absorption-bands in spectra.

R. & J. Beck.

3616b. Sorby's Volute Diaphragm, for regulating the amount of light for the spectrum microscope. *R. & J. Beck.*

3617. Early Form of Machine, with Knife, for making microscopical sections of wood, &c., devised by Andrew Pritchard, F.R.S.E., prior to 1835. *Dr. Urban Pritchard.*

The block of wood for section, if large enough, is fixed in the movable triangular chamber by means of the little screw. The larger screw at the bottom gradually elevates the whole, and the knife, held in both hands, shaves off thin sections as the wood is raised. Should the piece of wood be too small to be placed in the triangular chamber, it must be glued on to a block of convenient size.

The whole machine is made to screw on to a bench.

3618. Apparatus for Maintaining an even Temperature in Microscopic Observations.

Geneva Association for Constructing Scientific Instruments.

This instrument is intended for performing microscopic operations in a perfectly even temperature by means of hot water circulation. A small spirit lamp is placed under the reservoir at the extremity of the apparatus. A thermometer placed inside the instrument serves to regulate the temperature.

3619. Camera for Microscope.

Geneva Association for Constructing Scientific Instruments.

3620. Two Ross Compressors, for the Microscope. (Ordinary models.)

Geneva Association for Constructing Scientific Instruments.

3621. Compressor, by Schick, for the Microscope. (Ordinary model.)

Geneva Association for Constructing Scientific Instruments.

3622. Sector, with inclined plane for producing micros sections of extreme tenuity and regularity.

Geneva Association for Constructing Scientific Ins ments.

3623. Microtome by Professor Wilhelm His.

Geneva Association for Constructing Scientific Ins ments.

Many instruments for making micr scopic sections exist, but most of t have been distrusted by scientific men. This distrust was more or less just by the imperfection of the appar known hitherto, and it was mostly ferred to operate simply by hand, ut its being possible to calculate positive accuracy the thickness of t ection.

During the course of his studi on vertebrated animals, Professo His, of Basle, found the absolute n of an instrument for rapidly effe sections of positive regularity in thickness.

It is from his indications Geneva Association for Construc Scientific Instruments has con a Microtome, which has now the c plete approbation of the scientific men who have had occasion to use it.

The requirements were: 1, that the knife should be directed very accu while remaining independent of the pparatus; 2, that the object to be cised should be movable in a parallel e under the knife, and that the am of the displacement should be read with great accuracy; 3, that the ob should be fixed firmly in any position

The instrument consists of a table, 75^{mm} long and 60^{mm} wide, capab being inclined at will upon its foot. The table has a small tongue whi movable in parallel line by means of a micrometric screw indicating of a milimetre. To the tongue is affixed a stay, having a tightening sc under which is placed the object to be sliced. Above the table is a kn steel arch bearing a plane, perfectly adjusted, perpendicular to the table. is upon this surface that the knife, of which one side is also adjusted with greatest care, is made to slide by hand.

3624. Professor Vogelsang's Apparatus, serving to re the **temperature** of **Microscopic Objects.**

From the Collections of the Royal Polytechnic Schoo Delft, Professor T. Bosscha.

By this instrument it was shown that the air bubble in the liquid carb acid contained in quartz crystals ceased to be visible at a temperatur about 32° C. (Poggendorff's Annalen, vol. 137, table III., fig. 2.)

3625. Parallel Compressor, with micrometric screw, spec intended for the study of ova, and for observing the developm of lower organisms.

Geneva Association for Constructing Scientific Ins ments.

The upper cup takes off to admit the dissecting trough. The pressu effected by means of the side adjusting screw. By moving the disse trough with the hand a round body can be examined on all sides successi

The dissecting trough can hold a good quantity of water, of which no tion comes in contact with the metal, a favourable condition for the pres tion of live organisms.

3626. Dr. Burdon Sanderson's hot or cold Stage, for use with microscope, and with arrangement for gas.

T. Hawksley.

3626a. Boiler with incubating cells. *T. Hawksley.*

3627. Freezing Machine for making microscopic sections, by Professor Rutherford. *T. Hawksley.*

3628. Saccharometer, as accessory to the large microscope, from the same contributor. *R. Wasserlein, Berlin.*

The saccharometer is to be regarded as an accessory to the stage of the microscope. By this combination of two instruments (as the saccharometer can be fitted to smaller stages) cheapness is attained. The chief aim of the maker is to furnish a useful instrument, which at the same time shall be specially suited to the wants of the medical chemist in estimating grape sugar (as in diabetes). For this purpose the scale of the instrument is graduated so as to indicate in whole numbers and tenths the per-centage of grape sugar. For other substances a calculation is necessary.

3629. Woolmeasurer, fitting into the Student's Microscope. *R. Wasserlein, Berlin.*

This woolmeasurer, constructed by the exhibitor, is made at the express wish of Mr. Bohm, woolfactor at Leipzig. It affords the investigator the possibility of a complete command over stuffs composed of vegetable or animal fibres, as wool, silk, and all vegetable fabrics, so that they can be stretched and extended under the microscope; also in case the fibre is twisted, as in wool, it may be evenly stretched and turned round itself, so that its average diameter may be estimated. The apparatus allows the object which is thus stretched to be placed on a glass slide, so that it can be treated with acids, &c., and covered with a cover glass. All this can be done without preventing the manipulation described above. Threads up to a length of 1½ inch can be moved successively across the field of the microscope.

3630. Small Microtome, with an arrangement for the vertical elevation of the objects. *F. Süss, Marburg.*

3631. Larger Microtome, for the section of the spinal cord, with vertical elevation and divided circle. *F. Süss, Marburg.*

3632. Quadrant Microtome, for making microscopical sections at any given angle, with an arrangement for measuring the angle, and scale for showing the relative thickness of the section.

F. Süss, Marburg.

3633. Large Microtome, for cutting sections of the brain.

F. Süss, Marburg.

These microtomes are suited for embedding preparations. Samples of embedding preparations (soap mixtures), with instructions as to the use of the instruments, as well as the composition of the soap mixtures, are placed with the microtomes.

3634. Large Schiefferdecker's Microtome, with plate, two knives in case, glass bell jar, and tin mould for fixing preparations in an embedding mass. *F. Majer, Strassburg.*

which takes the place of a cover glass. By regulating the flame, the temperature in the chamber, which is kept moist by the drop of water which cannot evaporate, can be maintained perfectly constant for a long time, and the development of microscopical organisms at a high temperature can be observed.

3640. Two Cases of Microscopic Objects.
Voigt & Hochgesang, Göttingen.

3640a. Cases of Microscopic Preparations.
F. Enock, London.

3641. Microtome with Preparations, made by W. Apel, mechanician to the University of Göttingen.
Prof. W. Krause, Göttingen.

This microtome is accurately described in Waldeyer's and De la Valette's Archiv für microscopische Anatomie (earlier in Max. Schultze's Archiv), 1875, vol. XI., p. 216, plate XIII. It cuts in a purely mechanical manner, more by drawing than by pressing the knife, whilst any shifting either of the preparation or of the cutter by the hand is excluded by the principle of the construction of the microtome. The thickness of the section to be made can be read off on a circular disc divided into degrees, which can easily be applied to the instrument. Any other (much longer) knife can be substituted for the one in the instrument; the box in which the preparation is fixed can also be changed. The knife can be moistened by means of an "irrigator" with either alcohol or water, and the apparatus can be fastened to a wall so that the blade of the knife is horizontal. A microscopical preparation containing two sections of different thicknesses made with the above apparatus is enclosed for exhibition.

3642. Holle's Drawing Apparatus for the Microscope.
Cuno Rumann, Göttingen.

The construction of the apparatus has just been completed, and only one specimen has been made.

An account of its leading peculiarities will be found in the paper enclosed.

3643. Photograph of the Drawing Apparatus.
Cuno Rumann, Göttingen.

3644. Sectional View of Drawing Apparatus.
Cuno Rumann, Göttingen.

3645. Description of the apparatus of Prof. Grisebach, from the "Nachrichten von der Königl. Gesellschaft der Wissenschaften zu Göttingen."
Cuno Rumann, Göttingen.

3646. Dr. Thomas' Stages (*see also* X. 21).
Rud. Fung, Heidelberg.

3647. Querschnitter, an Instrument for cutting under the Microscope.
Prof. Dr. V. Karsten, Kiel.

The nature and use of the apparatus are given in the accompanying treatise. The instrument only differs from that described in having the curved piece (Bügel) turned forwards.

3648. Microtome, with four moulds, water-trough, wedge-shaped steel disc. *Prof. R. Möbius, Kiel.*

3649. Two Microtomes, with three moulds and steel disc. *Prof. R. Möbius, Kiel.*

A written explanation accompanies the objects exhibited.

3650. Five Moist Chambers, for microscopical research (after the designs of Recklinghausen, Ludwig, Geissler, de Bary, and Krebs). *Geissler & Son, Berlin.*

3651. Fritsch's Sliding Microtome.
Prof. G. Fritsch, Berlin.

The microtome, of which (on account of some recent alterations) an incomplete account is sent, has on its left a movable box for the reception of the object, on the right a pusher (Schieber) with eccentric screw as a holder for the knife. Other knives will be found in the lid for use, according to the degree of resistance offered by the object.

The object to be cut must be so placed in the metal box that the part to be cut projects over the upper rim of the box. The preparation is imbedded in a suitable mass, or is frozen in a mixture fit for cutting (*e.g.* Rutherford's). In the brown lacquered box are plates of spermaceti, and mixtures of the latter with cocoa-butter, suitably selected. Some alder pith is imbedded as a specimen.

After an advantageous position, as regards the object, has been given to the knife, and the object has been fixed in its little box by means of the screw of the large movable box, so that it can be cut by a gentle elevation of the movable box, the screws of the disk and knife are sharply drawn across. Should the position of the object be too low, one of the metal plates furnished with the apparatus is laid under the box, and the screw of the movable box again turned up, but not too quickly, in order to prevent the strain and pressure on the side of the box becoming too great. The work of preparing is automatic, so that when a clear section surface is obtained, the movable box, by means of the vernier attached, can be raised a definite fraction in height, and the object fixed in this situation; the knife screwed up on the slides is guided by means of the horizontal slot, whereby the uppermost part is taken off as a thin section. After drawing back the knife to the other end of the slot (turned from the operator), and a fresh raising of the box, a second section is obtained in a similar manner, and so on until the object is converted into thin sections. With objects difficult to cut it is necessary to moisten the blade during the cutting of the section with weak spirit contained in a wash bottle, one tube from which overhangs the blade, whilst the other is kept in the mouth for blowing. If the objects resist very much, so that the blade tends to give, then the safety of the section will be secured by laying the curved piece of metal from the mahogany box under the larger screw of the eccentric disk, and a corresponding tightening of the adjusting screw placed at the free end of the knife. The box for objects can (for the purpose of keeping the left hand for guiding) be easily fixed by means of a clamping screw through the slot.

Some sample sections are contained in the mahogany box.

3652. Counting Micrometer, for enumerating microscopical forms. To this is added a figure under glass, representing the micrometer magnified eight times.
Prof. H. Welcker, Halle an der Saale.

3653. Sliding Tray, carrying microscope lamp and Hartnack microscope, for demonstrating objects to a class.

W. R. M'Nab, M.D.

This tray runs on two rollers partly covered with india-rubber, thus destroying vibration, and permitting the tray to be used on an ordinary table.

3654. Mica-plates for preserving botanical and anatomical preparations. (*See* Mineralogy.) *Max. Raphael, Breslau.*

Mica-plates are conveniently employed for preserving hygroscopic anatomical preparations, such as of foliacious mosses ("Laubmoosen"), &c. For this purpose, the mica is split halfway through, and the preparation placed, in a moist condition, between the plates, which close of their own account owing to the elastic nature of the mica.

Should the preparations be required for examination, the plates have only to be dipped for a second or two into water; they may thus serve for years for repeated microscopic examination. It is obvious that covering plates of mica may be used for all botanical microsopic purposes.

3654a. New adjusting and self-centering Shadbolt's Turn-table for making microscopic cells.

Harvey, Reynolds, and Co.

3655. Knife for microscopic sections by Dr. Gower.

T. Hawksley.

3656. Knife for microscopic sections by Dr. Madox.

T. Hawksley.

3656a. Dr. Klein's Section Knife. *T. Hawksley.*

3657. Moist Chamber. *T. Hawksley.*

3658. Series of Glass Canulæ, and **Nozzle dissecting Instruments.** *T. Hawksley.*

3659. Three Diaphragms for microscope. *Laurent.*

3659a. Diaphragms (4), various. *Laurent, Paris.*

3660. Microscope Stand, medium size (stand No. 1 in the exhibitor's catalogue), with rack and pinion for the coarse adjustment, and with rotation round a vertical as well as horizontal axis, with five eye-pieces, and Abbé's illuminating apparatus. In a case.

C. Zeiss, Jena.

3661. A Set of Objectives, from 30 millimetres to 1 millimetre focal distance, in all 21 pieces. Some with the correction for cover glass. The whole in case with lock and glass lid.

C. Zeiss, Jena.

This collection embraces a complete set of microscope objectives, as contained in the catalogue of the exhibitor No. 21, 1874. Some of them are furnished with an "adapter," so as to suit the length of the tube of English microscopes. The threads are those of the "Society's screw."

3662. Preparations of normal anatomy of the human body, injected and varnished, in 1809, by Prochaska.

The microscope and preparations were given by the author to the first Baron Larrey, with the description in Latin that is affixed to the instrument. *Baron Larrey, Paris.*

3662a. Microscopic Section Cutting Machine, with Freezing Cell. *Harvey, Reynolds, and Co.*

3662b. Williams' Freezing Microtome. *J. Swift.*

3663. Microscopical Double Knife, constructed by A. Kelzig, surgical instrument maker in Prague. The broad blades are, at their free ends, bent towa each other (curved), and are flexible (elastic). Compared w knives of older shapes, the parallelism of the edges is to a much greater extent preserved thereby.

3664. Valvulotome. An instrument for making incisions in the valves of the heart, being a straight catheter, at whose front extremity, which is rounded, a small knife is attached, which by means of the screw-like motion of a piece of metal inside the catheter can be screwed round its lower fixed end, so that the free rounded end will be more or less moved forward. The edge of the knife is turned towards the catheter. After the introduction of the instrument into the jugular vein, or the carotid artery, the right or left ventricle of the heart can be easily reached. The knife having been moved forward, the chordæ tendineæ of the heart are grasped and cut off by pulling the knife backwards into the catheter. Artificial disorders of the heart so produced have been observed for more than a year, and the circulation studied on cymographical curves.

(Prague. Weekly Journal, '76. No. 2.)

The Imperial and Royal Pathological and Anatomical Institute of the University of Prague (Director, Professor Edwin Klebs).

3665. Microscopical Warm Stage. The constant equality of the temperature is obtained by the increased bulk of the thick copperplate. The object is placed in the recess, and the centre aperture of the latter is closed by a glass disc. A broad, thick copper ring with central aperture for the object is placed on the upper surface of the disc, thus closing the aperture. The lateral movement of the microscope with the coppering is effected by a plate at the bottom of the apparatus on which the microscope is fixed. The same can be shifted in two directions, at right angles to one another by means of micrometer-screws. Four side-apertures admit the introduction of thermometers or liquids for keeping the

chamber moist, or for the infusion of gas. A small gas-flame, which imparts heat to the adjoint-piece, serves as a heat conductor.

The Imperial and Royal Pathological and Anatomical Institute of the University of Prague (Director, Professor Edwin Klebs).

3668. Microtome. A circular knife is set revolving by a turning-lathe. The preparations, which are embedded in a metal case, are moved forward by a micrometer screw, and passed across the edge of the rotating knife by a contrivance similar to that in a dividing engine.

The Imperial and Royal Pathological and Anatomical Institute of the University of Prague (Director, Professor Edwin Klebs).

3668a.

II.—OPHTHALMOLOGICAL APPARATUS.

3669. Instruments for Extraction of Cataract. *Dr. Adolph Weber.*

3669a. New Telescope and collection of metrical glasses, for ophthalmology. *A. Nachet, Paris.*

3669b. Artificial Eye, by Dr. Landolt. *A. Nachet, Paris.*

3669c. Pupillometer, by Dr. Landolt. *A. Nachet, Paris.*

3671. Pupillometer. *Emil Stöhrer, Leipzig.*

3673. Hermann's Blemmatotrope, for representing Listing's law of the positions of the eye.

Professor Dr. L. Hermann, Zürich.

This apparatus can be arranged for vertical, horizontal, or oblique axes of rotation, by changing the position of the arcs which support the eye-balls. The same number that is marked by the arc on the edge of the fixed concave disc behind the eye-ball, must be crossed, on the equatorial ring of the eye, by the red (vertical) meridian. When the axis of rotation is vertical or horizontal, the blue (horizontal) meridian corresponds, during rotation, with the thin brass plate (visual plane); when the axis of rotation is oblique, the horizontal meridian and the visual plane will form an angle (the so-called Raddrehungs-Winkel).

3674. Tonometer, for Measuring the Tension and Convexity of the Eye-ball.

Geneva Association for Constructing Scientific Instruments.

... is specially used for glaucoma. It serves to produce a definite ... the eye, which may be variable at the operator's will, according ... suitable circumstances for a special case.

... instrument is composed of a rod, of which the ivory-tipped end presses ... and deforms the eye, while the other end acts upon a dynamometric ... ing, the flexure of which, amplified by a catch and by the indicating needle, ... in grammes upon the dial the pressure exercised upon the rod, and, consequently, upon the eye.

An index marks the greatest oscillations of the principal needle.

3675. Graefe's Tonometer (Augendruckmesser).

Dr. Weber, Darmstadt.

Graefe's tonometer has only a[illegible] value, since it was the first apparatus with which he endeavou[illegible] [illegible]asure the tension of the eye-ball tegument; it could not, however, be [illegible] [illegible]duced into practice on account of many inconveniences.

3676. Weber's Tonometer. *Dr. Weber, Darmstadt.*

3678. Rose's Schistoscope, for the physiology of colour.

F. Schmidt and Haensch, Berlin.

3679. Micrometer, for measuring objects in the fundus oculi.

Dr. Laqueur, Strasburg.

This apparatus is used for measuring in the living eye the real size of the "papille" blind spot, the diameter of the blood vessels of the retina, the size of the macula lutea, the distance of the latter from the external edge of the blind spot, also the dimensions of any extravasations of the retina.

For the method of using the apparatus, see the accompanying paper Centralblatt der med Wiss. 1873, No. 59.

It can also be used for determining the condition of the refrangibility of the eye in ophthalmoscopic examination, by placing the toothed part of the stems in front of the lamp which serves as a source of light.

An account of the apparatus is published in the Proceedings of the Ophthalmoscopic Society at Heidelberg for 1875.

3680. Dr. Förster's "Lichtsinnmesser."

R. Sitte, Breslau.

A source of light of constant intensity, but whose size can be varied, illuminates the object, which may be either black bands or large letters on a white ground. The source of light is surrounded with white paper, which is illuminated on the other side by a standard candle burning at almost the same height. The size of the source of light depends on an adjustable diaphragm, whose centre always remains at the same point. The diagonal of the square aperture of the diaphragm is measured by a scale which moves with the plates of the diaphragm. The size of the illuminated surface $= \frac{d^2}{2}$, if half a square millimeter be taken as the unit. Thus one can learn by means of this apparatus all quantities of light, from 1 to 2,500 units.

See Zehender's Klinische Monatsblätter fur Augenheilkunde, 1871, p. 337

3680a. Dr. Forster's Perimeter. *R. Sitte, Breslau.*

This apparatus is used for determining the external limit and the colour limit of the defects of the field of vision. The position of the displaceable objects is read off by meridians and parallels.

A more detailed description will be found in Zchender's Klinischen Monatschriften für Augenheilkunde, 1869, p. 411.

3681. Cohn's Refracting Ophthalmoscope.

Prof. Dr. H. Cohn, Breslau.

In the year 1871 the exhibitor constructed this apparatus for examining as quickly as possible a number of scholar's eyes. In 1872 the instrument was described in the Klinischen Monatsbl. of Augenheilkunde, in the October number. Twenty-four glasses can be quickly pushed past behind one and the same mirror. As the disc which bears these glasses is centred above the mirror, the nose of the observer cannot come into contact with it. There is no necessity to shift three discs with glasses, as in Loring's Ophthalmoscope. If the mirror be placed in front of the eye to be examined, and the patient looks through the central hole at some letters in the distance placed on an inclined table desk (as Snellen's alphabet), the instrument can be used instead of a test lens, and thus the wearisome selection of the glasses is avoided; in the same way, by quickly turning the disc with the correction glasses, its refrangibility for an object can be removed.

3682. Cohn's Exophthalmometer, three specimens.

Prof. Dr. H. Cohn, Breslau.

These instruments possess a certain amount of interest, as they are almost the first instruments which were made for measuring the prominence of the eye from the orbit. Dr. Cohn exhibited the first of the accompanying instruments, on Nov. 17th, 1865, before the Medical Society of Breslau, and at the same time gave it the name of Ophthalmoprostatometer; but later, in the year 1867, he changed the name to Exophthalmometer. The second instrument which accompanies the first Dr. Cohn has not publicly demonstrated, as he altered the principle of measurement; nevertheless he determined to send the instrument, so that one can judge of the reasons which induced him to regard the external wall of the orbit which he had taken as his fixed point (and is still so taken by some) as not suitable for the purpose. The third exophthalmometer with which the exhibitor finally carried out his measurements, was laid before the Ophthalmic Congress, at Paris, on the 12th of August 1867. Its peculiarities and applicabilities are described in the accompanying pamphlet.

3683. Several Pairs of Cohn's Mica Spectacles, manufactured by M. Raphael in Breslau.

Prof. Dr. H. Cohn, Breslau.

In February 1868 the exhibitor examined the eyes of 1,283 metal workers and, in consequence of the enormous frequency of injuries to them, caused the first pair of mica spectacles to be made. They cannot splinter, and are extremely cheap. They are recommended for workmen who manipulate explosive materials. In the accompanying pamphlets is shown the gradual perfection to which these glasses have been brought by the manufacturers, Messrs. Max Raphael, in Breslau, under Dr. Cohn's directions.

3684. Apparatus for giving Instruction in the use of the Ophthalmoscope; also 18 water-colour drawings in a box, giving the typical aspects of the retina in health and disease, from nature. *Dr. Magnus, Breslau.*

This apparatus presents, in a very instructive way, the various laws of refraction of the eye, by shifting the lens which is contained in it; the apparatus

About ten times the natural size. The cornea and lens are, as far as their optical values are concerned, as near as possible, imitations of the natural eye. The box is filled with water, containing a trace of quinine, and can be thus used for demonstrating the passage of the ray in the natural eye under differing conditions. By removing the lens the conditions of the eye after a cataract operation are represented. The plane cylindrical vessel filled with water can be used for illustrating astigmatism.

3691. Apparatus for demonstrating the **Reverse Position of the Image** on the retina of the observer's own eye. (Old.)

Prof. Dr. Dove, Berlin.

3692. Ophthalmometer, according to the directions of Professor Helmholtz.

Aug. Becker (Dr. Meyerstein's Astronomical and Physical Workshops), Göttingen.

3693. Mirror Apparatus for the above, for measuring the radius of curvature of the different meridians, with balancing weight.

Aug. Becker (Dr. Meyerstein's Astronomical and Physical Workshops), Göttingen.

The mirror apparatus is fixed into the opening of the index disc, which is placed at the further end of the ophthalmometer. The instrument must, when put into use, be so placed upon a stand that the long rods of the mirror apparatus clear the disc of the stand, when it is rotated. A weight, passing over the telescope, balances the instrument.

3694. Specimens of Transparent Drawing, showing cases of **Optical Illusion,** described in Prof. Helmholtz's Physiologische Optik.

T. A. Snyders, Lecturer at the Royal Polytechnic School at Delft.

To be used in the projecting apparatus of M. Duboscq. The figures are drawn in Indian ink on sheets of unpolished glass, which are afterwards rendered translucid by a thin layer of varnish.

3695. Graefe's "Leuchtscheibe" (illuminating disc); from the property of the late Professor von Graefe.

Dr. Weber, Darmstadt.

3696. Weber's Synamphophthalmoscope.

Dr. Weber, Darmstadt.

The apparatus serves for the simultaneous investigation of both eyes in the inverted image, and thus permits a comparison of the details of the background of the eye as to size, colour, &c. In using it a double source of light and a perforated reflector are required.

3697. Graefe's Binocular Optometer.

Dr. Weber, Darmstadt.

3699. Reflecting Stephanoscope.

Prof. Dr. Lommel, Erlangen.

(1.) The little apparatus is intended for the observation of interference phenomena produced by a dimmed (trübe) mirror. The mirror is at one

enc ... ass tube, which has a lateral excision, and contains a second tub ... end is cut off at an angle of 45° to the axis, and is there closed ... as. If the light of a candle is allowed to fall through the d aperture upon the plane glass, so that it is reflected vertically to the ... r, it will, on being viewed through the tubes, appear surrounded by ... ton's rings, which pass, when the tube is slightly inclined, into the so- ... d Whewell's bands. If a pencil of solar rays is caused to enter by the ... eral opening, and a lens of large focus is put on to the end of the second tube, the above images can be thrown upon a screen.

3700. Erythroscope. *Prof. Dr. Lommel, Erlangen.*

The erythroscope is an eye-glass of combined blue cobalt glass with red copper-suboxide glass, which gives passage only to the utmost red before line B. Since chlorophyll does not absorb this colour, the green parts of a plant appear, when viewed through the erythroscope, quite light coloured; the foliage of a tree in sunshine, for ... ce, will appear as light as a white cloud, and form a light spot upon the ... ground of the sky

3701. Melanoscope. *Prof. Dr. Lommel, Erlangen.*

The melanoscope, a combination of dark red copper glass and light violet glass, allows chiefly the re... tween B and C to pass, which are absorbed with avidity by plants. ... herefore through the melanoscope plants will look very dark, almost ... This contrivance and the preceding one show in an instructive manner ... plants absorb eagerly the middle portion of the red part of the spectrum, but not at all the ultra red.

3702. Erythrophytoscope I.

Prof. Dr. Lommel, Erlangen.

This combination of *Sammler*, consisting of blue cobalt glass and dark yellow iron oxide glass, transmits ultra red up to B, and also to yellow-green, blue-green, and blue. Leaves, looked upon through it, appear coral red, the sky blue, the cloud reddish-violet, the soil violet-grey.

3703. Erythrophytoscope II.

Prof. Dr. Lommel, Erlangen.

The erythrophytoscope II, combined of blue cobalt and light red copper glass, allows, besides ultra red, only blue-green and blue to pass. The effect is similar to that of the preceding combination, only more striking.

It should be remarked that, only vegetable and analin green appear, as described under these combined glasses; mineral green would look dark blue-green

3704. Coloured Gelatine Leaflets as objects for the spectroscope. *Prof. Dr. Lommel, Erlangen.*

To demonstrate the absorption phenomena of soluble colouring matters, plates of isinglass, which had been dyed with the colouring matter, are recommended, instead of the solutions. To protect these plates against dust, &c., they may be placed between two glass plates. By placing feebly coloured plates in a stair-like way upon one another, the increase of absorption by increasing thickness may easily be illustrated.

3705. Dr. Archer Warwick's Eudoscope.

T. Hawksley.

3706. R. B. Carter's Demonstrating Ophthalmoscope.
Thomas Hawksley.

3707. Dr. Lionel Beale's Demonstrating Ophthalmoscope. *Thomas Hawksley.*

3708. C. J. Oldham's First Ophthalmoscope, with one diaphragm at back of mirror to carry lenses. *Thomas Hawksley.*

3709. C. J. Oldham's Second Ophthalmoscope, with three diaphragms. *Thomas Hawksley.*

3710. Couper's Ophthalmoscope, with five discs. *Thomas Hawksley.*

3710a. New Optometer, with double refracting lens of calc-spar, give double readings, and greater precision in determining the distance of sight. *Professor Carl Wenzel Zenger, Prague.*

3711. R. Brudenell Carter's Perimeter for ascertaining the boundary of the field of vision and the area of the blind spot. *Thomas Hawksley.*

3712. Perrin's Artificial Eye Apparatus. *T. Hawksley.*

3713. Dr. Badal's Optometer. *M. Roulot, Paris.*

3714a. Messrs. Perrin and Mascart's Optometer. *M. Roulot, Paris.*

3714b. Dr. Badal's Perimeter. *M. Roulot, Paris.*

3714. Dr. Giraud Teulon's Binocular Ophthalmoscope. *M. Roulot, Paris.*

3715. Boxes of Metrical, Spherical, Cylindrical, and Prismatic Glasses. *M. Roulot, Paris.*

3716. Various kinds of Optical Glass. *Weslëin, Paris.*

3717. Set of Lenses for Trying the Sight. *W. Campbell & Co.'s successor, T. Wohlers, Hamburg.*

3717a. Box with Specimen Spectacles for Oculists. *W. Campbell's successor, F. Wohlers, Hamburg.*

3719. Metrical Ophthalmoscope, of Dr. de Wecker. In one zone are placed 20 convex glasses ascending gradually from 0·50 to 10 metrical dioptric. To obtain the concaves, a concave lens is interposed, more powerful than the maxima of the convex glasses (10½ dioptrics), and by turning the wheel a descending series of 0·50 to 10·50 concave dioptrics is obtained. *M. Crétès, Paris.*

3720. Weber's Photometer and Chromometer. *Dr. Weber, Darmstadt.*

3721. Weber's Chromoptometrical Tables. *Dr. Weber, Darmstadt.*

III.—WEIGHING AND MEASURING APPARATUS.

3722. Craniometer, by which measurements of crania may be taken rapidly and accurately.

Professor Struthers, Aberdeen University.

It is essentially a glass box, the panes accurately ruled and fitted into a carefully made brass frame. Sides 9 inches square; ends, bottom, and top, 9 inches by 7 inches. Bottom of strong plate glass. Top lifts out. Panes ruled both ways at distances of an inch [illegible] Middle division of each pane is halved by a median line, which is [illegible]s-marked at each ¼ inch. Skull placed so that middle line correspond- [illegible] middle line of panes. By looking through panes, and getting eye on [illegible] esponding lines of opposite pane, accurate measurements may be easi[illegible] rapidly read off of top, sides, front and back, or of interior of base. [illegible] outside of base, cranium is turned over and steadied. The cranium [illegible]ined in the craniometer is a well-marked specimen of the scapho-ceph[illegible] form, with the usual early obliteration of the inter-parietal suture. The [illegible]nstrument was made for Professor Struthers by Mr. P. Stevenson, philosop[illegible]ical instrument maker, Edinburgh. An account of this craniometer w[illegible]ven by Professor Struthers in the Edinburgh Medical Journal, 1868.

3722a. Craniometer, an instrument for taking measurements of the human cranium. *Geo. Busk.*

The instrument is constructed on the principle of the common shoemakers' gauge, and consists of a straight stem about 12 inches long, having an arm jointed to it at one end, which can be erected so as to stand at a right angle, and a second arm which can be slid up and down the stem, and is also capable of being erected to a right angle, so as to stand exactly parallel with the former. The stem and arms are graduated on one side in inches and tenths, and on the other in centimeters and millimeters. The graduation of the stem, begins at the fixed arm, and that on the arms from the stem. In order to render the instrument capable of taking radial measurements, a conical peg can be slipped upon each of the arms, the points of which are inserted into each external auditory foramen. The radial distance from the centre of the foramen can be thus measured to any point on the periphery of the skull in the mesial plane, the distance being read off on the short arms.

3727. Dr. F. W. Spengel's Craniometer.

A. Wichmann, Hamburg.

An account of the fixing of the skull, as well as the use of the apparatus, is given in the accompanying "Correspondenz-Blatt der deutschen Gesellschaft fur Antropologie, Ethnologie und Urgeschichte.

3728. Virchow's Portable Craniometer.

A. Wichmann, Hamburg.

3729. Virchow's Tactile Compasses (Æsthesiometer).

A. Wichmann, Hamburg.

3730. Virchow's Scale. *A. Wichmann, Hamburg.*

3731. Kephalograph or Craniometer, to determine the shape and dimensions of the human skull.

Dr. P. Harting, Professor at the University of Utrecht.

This instrument, which is intended to determine the shape and dimensions of the human skull, consists of three principal parts or distinct instruments.

The first (Fig. 1., Pamphlet) is intended to fit round the head, and to trace its principal circumference.

The second (Fig. 2) may be fitted lengthwise, crosswise, or in any other direction required.

The principal use of the third (Fig. 3) is to determine the profile of the face.

For further particulars, see the monograph "Le Kephalograph," by Professor Harting.

3723. A Balance for Physiological and Clinical Purposes, on polished oak.

The Brandenburg Balance Manufactory, Messrs. Kuhtz & Co., Brandenburg on the Havel.

These balances and weights are being extensively used in all scientific schools, and especially by practical physicians. They are available and almost indispensable for the investigation of the disturbances of nutrition in childhood; for the estimation of the loss or gain of weight by the body during the course of lung disease, diabetes mellitus, acute diseases, &c.; for the study of the normal growth of the body; and for pathological and anatomical investigations in which weighings are required.

The balance carries 150 kilogrammes and turns with 0·25 grm. By means of the pointer attached to the beam and the ivory scale, a still smaller difference in weight can be detected.

3724. Set of Iron and Brass Weights, accurately adjusted.

The Brandenburg Balance Manufactory, Messrs. Kuhtz & Co., Brandenburg on the Havel.

3732. Manometer, with movable level of the mercury.

Physiological Institution, Prague.

The above is a quicksilver manometer, the legs of which communicate with a vessel containing mercury; the bottom can be lowered or raised by means of a screw. The manometer allows, among other things, a very quick measurement of the pressure of the saliva, during secretion.

Professor A. Crum Brown's Preparations and Apparatus.

3733. Skull with internal ear prepared for the measurement of the relative position of the planes in which the semicircular canals are situated.

Two saw-draughts are cut through the outer table of the skull, forming a large angle with one another. These saw-draughts pass through the mastoid part of the temporal bone, and are continued into the neighbouring parts of the skull; two pieces of steel plate are cut so as to fit into the saw-draughts, and the position in which they fit indicated by marks on the plates and on the mastoid bone. The greater part of the mastoid and the whole of the petrous portion are thus sawn out, and the steel plates fixed to the portion of bone thus removed. This portion can now be replaced exactly *in situ* by placing the ends of the steel plates into the portions of the saw-draught remaining on the skull. The remaining portion of bone is now plunged into a bath of fusible metal, and placed under the receiver of an air pump. On exhausting, bubbles of air escape from the cavities in the bone, and on re-admitting air these cavities are filled with fusible metal. By repeating this operation ten or

tu times in different positions, all the air can be pumped out and the ca completely filled with fusible metal. The bone is now removed from .s of fusible metal, and the adherent metal removed. It is then placed ed paraffin, so as to cover the steel plates, and the greater part of the ...d portion. When the paraffin has solidified, the whole is placed in a vessel containing dilute hydrochloric acid. This dissolves the unprotected part of the bone, leaving a cast of the cavities in fusible metal. From this the casts of the mastoid cells are carefully removed. To the external part of the mastoid is now soldered a brass pin fitting into a socket in the large goniometer. The cast can then be brought successively into positions in which each of the canals lies in a horizontal ...ne. In each of these positions the skull is replaced by means c ...lates, and a glass plate fixed to the skull in a horizontal plane. ... are therefore parallel respectively to the planes of the canals; ... ative position can be ascertained by means of the goniometer. See ... s of the Royal Society of Edinburgh, January 1874, and Journal of Anat... nd Physiology, viii. 327.

...34. Skull of Owl, prepared to show relative position of the ...ircular canals of internal ear.

The strongly osseous tissue has been removed from the dense bones forming the canals, and these have been coloured so as to indicate the pairs of parallel canals.

3735. Skull of Crow, prepared to show relative position of the semicircular canals of internal ear.

3736. Skull of Heron, prepared to show relative position of the semicircular canals of internal ear.

3737. Cast, in plaster of Paris, of internal ears of the skate.

3738. Apparatus for measuring the relative **position** of the **planes** in which the **semicircular canals** of the **internal ear** are situated, with skull, illustrating its application.

The apparatus is simply a reflecting goniometer on a large scale. The telescope used with it is not sent, as it requires to be fixed at a considerable distance from the apparatus.

The mode of preparing the ear for observation is described above.

3739. Cast, in solder, **of human internal ear,** right side.

3740. Dynamometer for **Paracentesis Thoracis,** by Dr. Douglas Powell. *T. Hawksley.*

3741. Dr. Douglas Powell's Instrument for **measuring Thoracic Resilience.** *T. Hawksley.*

3741a. Instrument for the **Identification** of **Persons.**
Joseph Bonomi, 13, Lincoln's Inn Fields, W.C.

The normal proportion of the human frame is that the measure of the distance from the extremity of one hand to the extremity of the other when the arms are extended should be the same as that from the top of the head to the sole of the foot, and any departure from this normal proportion furnishes a means of individual identification.

e purpose of the instrument is to obtain these two measurements simul-
usly.
consists of two laths of wood fixed at a certain angle against a wall.
ı the centre of each lath is a groove in which slides an index to show
equired measurements. The third index below is for the purpose of
aining with great nicety the law of growth.

V.—CHEMICAL APPARATUS USED IN PHYSIOLOGICAL RESEARCH.

742. Closed Flask for **Experiments** in **Abiogenesis, &c.**
Professor D. Huizinga, Director of the Physiological Laboratory of the University of Groningen.

e neck of the flask is surrounded by a glass cylinder closed below so
ı circular groove is formed. When the liquid in the flask has been
l to boiling temperature, the flask is closed by the previously heated iron
ler, the under surface of which, as well as the mouth of the flask, have
carefully ground so as to fit accurately. The circular grooves at the
ıd bottom of the cylinder are then filled with heated mercury. The
ı now escapes through the axis of the cylinder. When ready for closing,
sufficient boiling, the lateral silver tube is heated by a pair of gas burners,
he bell-shaped iron cover is also heated and placed on the top of the
der so as to dip into the mercury of the upper groove. The flame under
ask is then removed. The air which now enters the flask must neces-
pass through the continually heated silver tube. If judged necessary,
ıner width of this tube can be reduced by passing through it a platinum

abiogenetic experiments a hatching apparatus is then applied to, but
ıut touching, the flask, so that during the whole experiment the silver
remains exposed to the flames of the burners.
e lateral iron bar with the movable weight serves for equilibrium, so as
ure a firm position for the whole on the mouth of the flask.

743. Dialyser.
Professor D. Huizinga, Director of the Physiological Laboratory of the University of Groningen.

piece of parchment is glued on both sides of an ebony frame, and strips
ıe same material are glued about the edges, and thus is formed a
ctly tight bag. The whole is then exposed to diffused daylight, the super-
s bichromate removed, and the dialyser is ready for use. The glue
is a mixture of gelatine and bichromate of potash.
e dialyser can be tested thus :—

When the paper is dry and water poured in, no perceptible drops of moisture, even after long standing, ought to appear on the outer surface.

A fresh solution of hæmoglobine (diluted fresh blood) being poured in, and the dialyser placed in water, should the red hæmoglobine appear in the water the apparatus is defective.

r further particulars respecting this apparatus *see* "Archiv für
iologie," Vol. xi. p. 392.

744. Two Self-acting Filtering Glasses, for microscopi-
eagents. *Prof. Jessen, Eldena, in Pomerania.*

V.—THERMOMETRIC APPARATUS USED IN PHYSIOLOGICAL RESEARCH.

3745. Clinical Thermometers, made upon Dr. Phillip's principle. *Francis Pastorelli.*

The ball and part of the stem are filled with mercury; above the main column, separated by an air speck, is a small mercurial index; when heat is applied to the ball the column and index are driven forward; on cooling the main column only recedes, the index remains, the upper end of which indicates or measures the amount of heat applied. Above the air speck the space is a vacuum.

3745a. Dr. Clifford Allbutt's Clinical Thermometers; Fahr. and Cent. scales; various patterns. *Harvey, Reynolds, and Co.*

The general introduction of the thermometer for ascertaining the temperature of the body in disease indicates one of the chief advances in the methods of diagnosis.

Dr. Aitken used thermometers 10 inches long, and the instrument was hardly met with beyond the wards of a few hospitals. In 1868, Dr. Clifford Allbutt requested Messrs. Harvey, Reynolds, and Co. to make him instruments with a chamber anterior to the bulb, reducing the length of the tube from 10 inches to 6 inches, then to 4 inches, and to 3 inches From that time the use of the clinical thermometer has rapidly extended, until now it is found in the pocket of almost every medical practitioner.

3745b. Clinical Chart Forms for temperature, &c. *Harvey, Reynolds, and Co.*

Quarto size for hospitals; octavo size for medical practitioners and their patients. Designed by Edward Casey, M.D., Windsor.

3746. Standard Thermometer, for physiological purposes, 0°–50°, divided into $\frac{1}{10}$° (Virchow). *Geissler & Son, Berlin.*

3747. Standard Thermometer, for physiological purposes, 30°–45° (Heidenhain). *Geissler & Son, Berlin.*

3748. Two Pocket Maximum Thermometers, for the use of physicians, in a case and ebonite sheath. *Geissler & Son, Berlin.*

3749. Geissler's Standard Thermometer, for determining the temperature of the skin, divided into $\frac{1}{10}$°. *Geissler & Son, Berlin.*

3750. Geissler's Standard Thermometer, for determining the temperature of the ear. *Geissler & Son, Berlin.*

3751. Rosenthal's Electrical Thermometer, for determining animal heat. Constructed by Dr. A. Lessing, of Nuremberg. *Prof. Rosenthal, Erlangen.*

The electro-thermometer consists of a bundle of iron and German silver wires, which is contained in an elastic catheter, and can be easily introduced

into any cavity of the body. It serves for the measurement of the temperature of the body in different places, and especially for lecture demonstrations. The resistance of the exhibited example = 0·25 Siemens' units. For introduction into the heart, *e.g.*, by the jugular vein, a smaller sized instrument must be used.

3752. Circulation Thermometers, in pairs, 12″ long, divided from 35° to 45° centigrade. *T. Hawksley.*

3752a. Dupré's Thermometer, with spiral bulb and silver reflector, for ascertaining the temperature of the surface of the body. *T. Hawksley.*

3752b. Pair of Clinical Thermometers. *E. Cetti & Co., London.*

3752c. Three Clinical Thermometers, in cases. *E. Cetti & Co., London.*

3752d. Two Page's Regulators. *E. Cetti & Co., London.*

3752e. Giessler's Regulator. *E. Cetti & Co., London.*

VI.—APPARATUS FOR INVESTIGATING THE FUNCTIONS OF CIRCULATION AND RESPIRATION.

3753. Model of Hermann's Heart Pump. *Professor Dr. L. Hermann, Zürich.*

This apparatus, exhibiting the use of the auricle, may be applied in connexion with Weber's model of the circulation of the blood. The auricle (the narrow chamber of the pump), without entrance valve, works in such a manner that the heart receives blood from the veins both during the systole and the diastole of the ventricle (the wide chamber). When the play of the auricle is prevented, by shutting off its piston from the lever, the heart receives blood only during the diastole of the ventricle.

3754. Apparatus for Artificial Respiration.

Professor Stricker, for the Institute for General and Experimental Pathology, Vienna.

The apparatus consists of clockwork set in motion by two steel springs, each five centimètres wide, and 598 centimètres long. The clock moves bellows, through which an animal, narcotized for the experiment, can receive sufficient air to maintain circulation.

To give the clockwork (made by Siegfr. Marcus, of Vienna) a uniform movement, Professor Stricker has constructed a regulator the principle of which is that with increasing velocity in the rotation of a balance wheel, two rods are thrown from the plane of the wheel, which act against a brush and so diminish the velocity. As the position of the brush can be regulated, the checking of the velocity can be commenced at any time within certain limits.

The clockwork can be made to work the bellows from 12 to 160 times per minute.

3755. Lowne's Patent Portable Spirometer.
R. M. Lowne.

The measurement of the vital capacity is obtained by measuring the velocity of the expired current during the time of expiration, and the instrument is arranged so as to reduce the velocity of the current to cubic measure. The indications of the instrument are shown by means of hands revolving on a dial which denote the number of cubic inches expired.

3755a. Improved **Portable [illegible]ireometer.** *E. Cetti & Co.*

3755b. Hæmotachom[illegible] Vierordt (1857).
Professor Vierordt, Tübingen.

The stand to be used with the [illegible]nt is omitted.

3756. Pump for Transfu[illegible]a of the Blood. Invented by Dr. Valentin.
Geneva Association for [illegible]onstructing Scientific Instruments.

This instrument is noteworthy [illegible]h of its being composed of a glass cylinder, thus making visible the p[illegible] of air in the pump. The piston also is made of a single piece of g[illegible]which ensures the greatest possible cleanliness

3756a. Blood Transfusor. *Collin and Co., Paris.*

3756b. Spiroscope. *Collin and Co., Paris.*

3756c. Aspirator of Liquids. *Collin and Co., Paris.*

3756d. Apparatus for delicate Injections.
Collin and Co., Paris.

3756e. New Spiral Setter. *Collin and Co., Paris.*

3756f. Hematimeter, apparatus intended to determine the number of globules in the blood, by Dr. Hagen and A. Nachet.
A. Nachet, Paris.

3757. Sphygmograph of Vierordt (1853).
Professor Vierordt, Tübingen.

The pad for fixing to the arm with the weights for equilibrating the instrument are omitted

3758. Photo-sphygmograph, with magnesium lamp, condenser, and plaster cast. *Dr. S. Th. Stein, Frankfort.*

This apparatus is used for photographing the human pulse. See Vogel's "Photogr. Mittheilungen," September and October 1875. Specimens of the photographs, a normal and fever pulse tracing, accompany the instrument.

3759. Sphygmodynamometer, an apparatus for estimating the blood pressure in the radial artery of man.
Dr. C. Friedländer, Strassburg.

The apparatus is made for determining the variations of the blood pressure in the radial artery in man; *e.g.*, the diurnal variations, the changes which the blood pressure suffers under the influence of poisons and various physio-

logical and pathological conditions. Thus the apparatus is actually intended for purposes different from those of the sphygmographs which have been hitherto described, but it can also be used as a sphygmograph. A description of it will shortly be published in a physiological journal.

3760. New Sphygmograph (Sommerbrodt's).
Dr. Sommerbrodt, Breslau.

This sphygmograph transfers the movements of the wall of the blood vessel to a point moving up and down vertically by means of a one-armed weighted lever, and has a contrivance for fixing, which excludes, especially in researches on the radial artery, any vibration of the apparatus.

The performance of this apparatus in relation to the already known characteristics of the pulse curves surpasses in a striking way that of Marey's sphygmograph, which has hitherto been universally used, and which depends on the action of a spring. Besides, it has been possible, with the help of this apparatus, to make a series of new observations on the pulse curves given by the radial artery, and to discover some completely new features which it presents. The details of these observations are given in a paper published in March of the present year, which bears the following title :—" Ein neuer Sphygmograph und neue Beobachtungen an den Pulscurven der Radialarterie von Dr. Julius Sommerbrodt, Privatdocent, Breslau. A. Gorschorsky's Verlagsbuchhandlung (Adolf Kiepert).

3761. Riegel's Double Stethograph. *Weber, Würzburg.*

The double stethograph as well as the sphygmograph may be used and experimented with a " clinique " under careful direction. As a guide to the stethograph, Dr. Riegel's treatise to " Die Athembewegungen " is added. It can be purchased, bound, for 9 marks. The double stethograph described in it is indeed of less recent construction, and is much dearer, but substantially the description answers perfectly.

3762. Sphygmograph. *Weber, Würzburg.*

3763. Pneumatometer. *Dr. Waldenburg, Berlin.*

This instrument consists of a manometer, one limb of which is connected by means of a tube with a mask for the face. It is used for measuring the force of inspiration and the force of expiration in healthy and diseased individuals. In persons who suffer from diseases of the organs of respiration, the instrument not only gives the measure of the strength of inhalation and exhalation as such, but especially records the relative proportion in which each function is modified, so that in certain diseases the force of inhalation is principally or entirely affected ; in others, the force of exhalation ; and in others finally, both are affected. In this way the pneumatometer serves as a new physical expedient for the diagnosis of disease.

3764. Kymographion, for the registration of the pressure of the blood and of the respiratory movements on a blackened surface of 250 centimetres long and 23 centimetres high, which may be changed for another within half a minute.
Physiological Institution, Prague.

Accessory apparatus are used for the blackening and for fixing on the black. Two quicksilver manometers, one spring manometer, and a drum recorder. Many may be put into action, either singly or together. An electro-magnetic signal apparatus marks every single and every fifth second.

similar signal apparatus serve in connexion with two differently con- ...etric double keys for marking the beginning or end of the electric ... other effects. The rapidity of the movement of the blackened ... variable within wide limits.

3765. Apparatus for Artificial Inspiration and Expiration. *Physiological Institution, Prague.*

Two pumps working synchronously, one of which is devoted to inspiration, the other to expiration. The number and depth of the respiratory acts are variable within wide limits. ... atus allows also the employment of mixtures of gases and the ... f the air expired without any loss.

3766. P... pparatus, with constant pressure, for arti... d and lymph vessels. *...ysiological Institution, Prague.*

By means of this apparatus eve... ressure between 2 and 300 mm. of ...rcury can be produced, and it re... ns unaltered during the whole continuance of the injection. The appa...us may be used for the simultaneous injection of two groups of vessels

3767. Scheme of the ... ation. *...ysiological Institution, Prague.*

The apparatus consists of two glass cylinders, communicating by a horizontal tube, one representing the arterial, the other the venous, system. In the horizontal tube there is, in imitation of the capillary system, a sponge, in which the resistance to the current may be diminished or increased at will by means of a screw. A small pump brings the fluid with the desired force, or in the desired quantity, from the venous into the arterial system.

3768. Gassphygmoscope, by Sigismund Mayer. *Physiological Institution, Prague.*

The apparatus consists of a small drum or capsule placed on the skin above a beating artery, through which common coal gas is allowed to flow towards a flame Each pulsation causes a contraction of the flame, and shows, among other things, very plainly the dicrotism of the pulse.

3769. Apparatus for the Registration of the Respiratory Movements. *Physiological Institution, Prague.*

The above consists of an air-tight case containing a living animal, which breathes through a tube fastened in the trachea. This tube communicates with the atmosphere through the side of the chest. The air enclosed in the chest is moved in oscillations of pressure by the breathing of the animal, and these oscillations are registered on the kymographion.

The apparatus allows at the same time the registration of the pressure of the blood, the section of the nervi vagi, the irritation of any desired nerves, and the injection into the jugular vein, without opening the case.

3770. Apparatus for **Registering** the **Respiratory Movements.** *Physiological Institution, Prague.*

In this apparatus the animal breathes out of a large air-tight closed receiver, which communicates with the trachea by a tube. The changes in the pressure of the air in the receiver, thus produced, are shown on the kymographion. The air in the receiver is frequently renewed.

3771. Apparatus for the **Demonstration** of the mechanical influence of the **Action of Breathing** on the circulation of the blood. *Physiological Institution, Prague.*

3772. Sphygmometer by Dr. Handfield Jones.

3773. Sphygmometer by Dr. Sibson.

3774. Stethometer by Dr. A. Ransome.
Thomas Hawkesley.

3775. Dr. A. Ransome's Stethograph for delineating the movements of the ribs during respiration. *Thomas Hawksley.*

3776. Dr. Burdon Sanderson's Kymograph, arranged for taking continuous ink tracing of the movements of the arteries. *Thomas Hawksley.*

3777. Dr. Burdon Sanderson's Kymograph with smoked cylinder for spiral traces. *Thomas Hawksley.*

3778. Dr. Oliver's Kymograph, with Sanderson's Cardiograph and Marey's Tambour, arranged for spiral traces, for use at the bed side. *Thomas Hawksley.*

3779. Five hundred yards of Paper for continuous traces.
Thomas Hawksley.

3780. Dr. Burdon Sanderson's Cardiograph for recording the movements of the heart. *Thomas Hawksley.*

3781. Dr. Burdon Sanderson's Stetho-Cardiograph for recording the movements of the chest and the heart.
Thomas Hawksley.

3782. Marey's Sphygmograph, with improvements by Sanderson, Sibson, and Handfield Jones, for recording the motion of the pulse. *Thomas Hawksley.*

3783. Dr. F. Sibson's Cardiograph for right and left ventricles and apex of heart. *Thomas Hawksley.*

3784. Marey's adjusting Pneumatic Tambour.
T. Hawksley.

3785. Electro Marker. *T. Hawksley.*

3786. Electro Magnetic Marker. *T. Hawksley.*

3787. Voit's Apparatus for investigating the gases given off in the respiration of small animals, exhibited in the Physiological Institute of Munich. *R. Stollenreuther, Munich.*

3788. Box containing **Apparatus** for the direct **Transfusion** of the **Blood**:—

1. A regulating canal formed by two tubes.
2. Three canals terminating in olive wood, shaped like a clarionet reed to insert in the arteries of animals.

3. ... and lancet.
4. ... canals of steel, reel-shaped, to fix in the regulating ... l.
5. Two pincers for compression.
6. Tube of gum elastic for joining the regulating canals to the arterial canal.

More detailed explanations as to the mode of setting up the apparatus, and the different positions of the internal tube as to the regulating canal, will be found in the description of the apparatus, two copies of ... with sketches and plans, are appended.

Dr. Giuseppe Albini, Pro... or of Physiology in the Royal University of Naples.

VII.—ELECTRICAL APPARATUS USED IN PHYSIOLOG...

3789. Hermann's Universa. Commutator, with adjustable contact-springs. *Professor Dr. L. Hermann, Zürich.*

This apparatus may be turned by hand or by water power, and admits of many physical and physiological applications, *e.g.*: 1. Closing a simple electrical circuit ("interrupter"). 2. Change of direction in a simple electrical current ("inversor") 3 The same in two circuits, for instance, in determining resistance in a polarizable conductor, by Wheatstone's method, under currents of changing direction. 4. Choice between opening or closing induction currents (Dove's "Disjunctor"). 5. Determination of the polarization residuum in a conductor after shutting the current (like Siemens's "Commutator") 6. Comparison of two residua of polarization, by connecting the two conductors with the galvanometer, one opposite to the other. 7. Many physiological rheotomic inquiries.

3790. Hermann's Non-Polarizable Electrodes, of large form. *Professor Dr. L. Hermann, Zürich.*

By this apparatus a nerve may be connected with any number of non-polarizable electrodes in a small space, for instance, in the wet chamber of a myograph. The ends of the zinc wires, well amalgamated, receive a covering of clay, mixed with saturated solution of sulphate of zinc, and above this a small quantity of clay mixed with 0 6 per cent. solution of chloride of sodium.

3790a. Becquerel's Thermo-Electric Apparatus for Physiological Purposes. *M. Ruhmkorff.*

3791. Electric Excitors. *T. Hawksley.*

3792. Daniell's Constant Current Batteries for Clinical use. *T. Hawksley.*

3793. Dr. Herbert Tibbit's Current Battery and Induction Apparatus. *T. Hawksley.*

3793a. Electro-Medical Pocket Case.

M. Trouvé, 6, Rue Thérèse, Paris.

This contains a battery, an induction coil, and all the accessories used in the practice of electro-therapeutics. (See pamphlet of Dr. Althean, translated by Dr. Davin, Paris, Delahaye.)

3793b. Large Electro-Physiological Apparatus.

Messrs. Trouvé & Onimus. *M. Trouvé, 6, Rue Thérèse, Paris.*

This apparatus, intended for electro-therapeutics, is at the same time very valuable for physiological experiments; it is the only one that produces induced currents strictly co-equal, whatever their number. In a given time, it shows instantaneously, and at will, the exact number of interruptions of the current corresponding with the electro-muscular shocks desired to be produced per second. It unites all the conditions requisite for making an exact study of the electro-physiological phenomena, and enables the process of tetanus in a muscle to be observed.

3793c. Electric Exploring-Extractor.

M. Trouvé, 6, Rue Thérèse, Paris.

This serves to diagnose of the presence in the organism of any foreign substance, metallic or otherwise, its nature, whether lead, copper, iron, wood, stone, &c.; the direction it has taken, its depth, and thus to facililate its extraction.

3793d. Portable Electro-Therapeutic Apparatus, with equal and continuous Current.

M. Trouvé, 6, Rue Thérèse, Paris.

This apparatus, specially intended for electro-therapeutics, is composed of:—

1. A battery of 80 elements, simply moist.
2. Of an apparatus at the same time of collector and commentator, for graduating the tension of the battery, and altering the direction of the current.
3. Of a galvanometer intended to register the passage of the current; the whole enclosed in a very portable case. Each element is constituted similarly to battery No. 3793g.

3793e. Apparatus for Galvano-cautery, by G. Trouvé.

M. Trouvé, 6, Rue Thérèse, Paris.

This apparatus, specially intended for surgical operations, takes up a very small space, and is composed of moveable elements enabling the practitioner to replace by himself, without the help of a specialist, the carbon and the zinc. The cauteries resulting therefrom are isolated by fuzed porcelain, which serves to resist all temperatures and all causes of deterioration.

3793f. Hermetical Battery, by G. Trouvé.

M. Trouvé, 6, Rue Thérèse, Paris.

This battery works only when reversed or placed horizontally; the zinc and carbon of which it is composed take up only the upper part of the sheath, made of hardened india-rubber; the other half, the lower, contains the stimulating liquid, water and bi-sulphate of mercury. This battery works the electro-medical case by the same inventor, as also his electro-physiological apparatus and his electric exploring extractor.

[illegible] **Moistened Battery, with constant Action.**
M. Trouvé, 6, Rue Thérèse, Paris.

[illegible] is composed thus :—Between two discs, one made of copper [illegible] other of zinc, forming the two electrodes, are piled rounds of blotting [illegible]. The lower half of these rounds is previously saturated with sulphate [illegible] copper, the other half with sulphate of zinc. It is continuously uni-[illegible], and lasts a long time. It is applied with great efficacy to electric clockwork, to telegraphy in general, and to all electrical apparatus having [illegible] circumference. Moreover it forms part of several apparatus [illegible] particularly of the "military telegraph," the [illegible], &c., &c.

VIII.—APPARATUS FOR INVESTIGATING THE FUNCTIONS OF MUSCLES AND NERVES.

3794. Muscle Telegraph. *T. Hawksley.*

3795. Apparatus for investigating the **action** of **Poisons on Muscles.** *T. Lauder Brunton.*

3796. Double Lever Apparatus for demonstrating the movements of the auricles and ventricles. *T. Lauder Brunton.*

3797. Apparatus for demonstrating the influence of **Heat and Cold** and the **action of Poisons on the Frog's Heart.** *T. Lauder Brunton.*

3798. Rosenthal's Rotating Myographion, constructed by Th. Welmann, of Munich. *Prof. Rosenthal, Erlangen.*

This myographion, lately constructed by the exhibitor, and not hitherto described, consists of a large glass plate, which is swiftly rotated by a weight [illegible] a horizontal axis. As soon as the desired velocity is attained, the glass plate is slightly displaced parallel to itself in the direction of its axis. It makes [illegible] revolution in its new position, and then returns of itself to its original position in order to keep on rotating. Whilst this one revolution is taking place the excitation and contraction curves are marked by a very simple mechanism. The time of duration can be exactly determined by a simultaneous tracing of a tuning fork curve. For investigations on reflex [illegible] especially for measuring the time of the (so called by the exhibitor) "[illegible]" (cross conduction), a contrivance is made by means of which two muscle curves can be simultaneously traced.

In order to determine very exactly the point at which the contraction curve commences, the movement of the left of the muscle is very considerably magnified. As the form of the muscle curve given by this apparatus cannot be depended on, it will not serve for studying its actual details.

The time of revolution of the glass plate may vary from two to half a second. It was impossible to measure with any apparatus hitherto constructed a space of time of such length with sufficient rapidity.

The linear velocity of the instrument revolving at its quickest rate amounts to about 2.5 m. in a second; values of 0·001 second can thus be easily measured.

3799. Methods of Physiological Experiments and Vivisections. Methodik der physiologischen Experimente und Vivisectionen, von E. Cyon ; with Atlas, published by Ricker, of Giessen and Petersburg, 1876.
Physiological Institute, Leipzig (Prof. Kronecker).

3800. Apparatus for demonstrating the Pulsations of the Frog's Heart. *Physiological Institute, Leipzig.*

3801. Canula for the frog's heart apparatus.
Physiological Institute, Leipzig.

3802. Pendulum Commutator.
Physiological Institute, Leipzig.

3803. Double Myoscope for the examination and demonstration of the laws of muscular contraction.
Physiological Institute, Prague.

The apparatus allows two nerves to be placed in a damp chamber, at the same time in opposite directions, and to be traversed by the same electrical current. The contractions of the muscles connected with them may be read on two dials.

3803a. Dr. Sibson's Improved Gastric Canulæ.

3804. Professor Foster's Levers for recording the **Movements** of the **Muscles, Nerves, &c.** *T. Hawksley.*

3805. Different Modifications of the **Spring Myograph** of Du Bois-Reymond. *Professor Theodore Schwann, Liége.*

A diapason or sounding fork is added, with a hammer to make it vibrate. By turning the handle placed on the left-hand side the hammer is freed in the first instance, and in the following moment the blackened glass plate. Excitation is caused by means of an induction coil. Previous to the freeing of the glass plate, and at the commencement of its motion, the current from the pile is interrupted, because it has to pass through the small insulated spring placed underneath the frame, and through the frame itself. But the latter has fixed to its under edge, on the right-hand side, a small ivory plate, which interrupts the metallic continuity. The excitement takes place just as the frame commences, in its motion, to touch with its brass surface this spring. An instrument fixed to the rod which carries the muscle enables the horizontal and the curved line of the muscle to be traced during the same experiment. Various other modifications of detail.

3806. Muscular Balance.
Professor Theodore Schwann, Liége.

This apparatus was exhibited to the meeting of German naturalists at Jena in 1836. It is intended to demonstrate that muscular contraction takes place in accordance with the laws of elastic bodies. At that time the means of producing the continuous contraction of a muscle were not known. In order to determine the degree of contraction without a load or with increasing

[illegible]

II.—ANTHROPO[illegible]

[illegible]. Anthropological [illegible]

[illegible]

42. Diopter, by "Wirsig."
43. Camera, "Wollaston's."
44. Diagraph, by "Tavard," modified by Broca.
45. Designer, by Broca.
46. Pantograph.
47. Parietal toniometer, by M. Quatrefages.
48. Occipital level, by M. Broca.
49. Arteria basileris level, by M. Broca.
50. Occipital toniometer, with dial, by M. Broca.
51. Do. do. rectangular, by M. Broca.
52. Caliper compasses, treble-armed, by M. Broca (2).
53. Auricular toniometer, treble-armed, by M. Broca.
54. Cephalic fan, by Second.
55. Rhinometer.
56. Intra-cranium holder.
57. Sphenoidal key.
58. Optical probe.
59. Turisk key.
60. Acoustic intra-cranium probes (2).
61. Optical-occipital probe.
62. Double disk for reconstructing compasses.
63. Cranioscope, by M. Broca.
64. Pivot, by Charles Bell.
65. Frame, by Pierre Camper.
66. Double frame, by Luca.
67. Frame, by Leach.
68. Craniometer, by Barclay.
69. Craniometer, by Bernard Davis.
70. Do. by Busk.
71. Toniometer, by Morton.
72. Apparatus, by Mantegazza.
73. Spindle.
74. Standard litre measure.
75. Half litre measure, graduated.
76. Funnel, with its operculum.
77. Double litre measure.
78. Shaft (*or handle*).

X.—SPECIAL COLLECTIONS.

[P]HYSIOLOGICAL AND OPHTHALMOLOGICAL INSTRUMENTS CONTRIBUTED BY THE PHYSIOLOGICAL LABORATORY AND OPHTHALMOLOGICAL SCHOOL AT UTRECHT.

[3]951. Moist Chamber for micro-biological researches.
Prof. Engelmann, Utrecht.

[M]etallic box, length 80 mm., width 40 mm., depth 7 mm., thickness of the [si]des 8 mm., bottom, a glass plate. Lid with central opening 15 mm., [dia]meter closed hermetically by a glass cover.
[D]rop with object to be placed underneath the covering-glass. Some drops of [wate]r on the glass bottom keep the chamber moist. The lid is pressed [agai]nst the upper surface of the chamber by two steel springs. If air-tight [closi]ng is required the edges of the lid are greased. Each of the small side s

its movements on a revolving cylinder, and at the same time presses on a tympanum, which communicates through an india-rubber tube with a Marey's cardiograph. If the cardiograph is made to register on the cylinder immediately under the spring, both curves may be compared. When the disc rotates slowly both curves are alike; with increasing velocity the difference augments. (Compare the curves; some are an imitation of physiological curves.)

3956. Brondgeest's Pansphygmograph. To register the movements of respiration, the beating of the heart, and the pulse of different arteries. *Dr. Brondgeest, Utrecht.*

The little box contains:
1. Cylinder, with internal spring, to be wound up by the hand.
2. Two Marey's sphygmographs to register on the blackened cylinder simultaneously respiration and pulse curve.
3. Little box with pens, to register, if desired, with ink on white paper.
4. A large tympanum, to register respiration, to be fastened with a tape round the chest or stomach.
5. Tympanum, with wooden plate and pin enclosed in a hoop, to be applied on the heart or on an artery.
6. Glazed papers for the cylinder.
7. Curves of respiration and pulse obtained simultaneously with the instrument.

3957. Scheme of the Circulation of the Blood (for instruction). *Prof. Donders, Utrecht.*

An elastic bag with valves sucks water up from a vessel. By repeatedly pressing on the bag (with a lever) undulations are determined either in a glass or into an elastic tube, producing an interrupted or a continuous flowing out. On a long bent elastic tube the simultaneous existence of streaming and propagation of waves is further shown, and by means of two little springs on adjoining places of the tube the velocity of propagation of the wave is demonstrated, and if desired registered (also with different pressures indicated by a manometer). The tube at the same time offers an opportunity for auscultation before and behind a dilatation. (Compare Donders, Physiologie des Menschen. Leipzig, B. I, p. 78. Zweite Ausgabe, 1859.)

3957a. Prof. Rutherford's Model of the **Circulation** for explaining the **Blood Pressure** and the **Pulse.**
Prof. Rutherford, Edinburgh.

Model of the circulation for explaining the blood pressure and the pulse. The tubes are filled with water. The heart is represented by an elastic pump. The apparatus is fully described in the Journal of Anatomy and Physiology, Vol. VI., p. 249.

3958. Scheme of the relations of **Pressure** in the mechanism of **Respiration.** *Prof. Donders, Utrecht.*

A glass cylinder (thorax), closed underneath by an elastic membrane (diaphragm), at the top by a stopper with three openings: 1st, for a tube (trachea) with india-rubber bladder (lungs); 2nd, for a manometer, communicating with the space in the cylinder; 3rd, for a tube to regulate the pressure of the air in the thorax. This pressure is made negative, as it is in reality; which causes the air to enter the india-rubber bladder, and the diaphragm to become convex upwards. By pulling the diaphragm down (inspiration) the pressure in the thorax decreases and the lung is more distended; the resistance of the lung is the negative pressure indicated by the manometer, Instead of an india-

rubber bladder a fresh lung of a dog or of a rabbit may be used. The space in the cylinder outside the bladder is of no consequence, as not modifying the pressure on the inner surface of the wall.

3959. Electrodes, with moist chamber for physiological researches. *Prof. Donders, Utrecht.*

a. Non-polarizable, consisting of glass tubes, at the thin bent end having an aperture closed by moist salt-clay, continued in the lower part of the tube; on this clay the nerve is spread. The tube is further filled with a solution of sulphate of zinc, wherein is a rod of amalgamated zinc.

1. Four of these electrodes on a stand between a vice reaching into a moist chamber of glass, two for a polarizing current, two for a stimulating current on the extended nerve. (Compare Donders, Onderzoekingen gedaan in het physiologisch laboratorium, Ser. III., I. p. 1, 1872, and Pfluger's Archiv für Physiologie [illegible], p. 1.)
2. Four coupled with changeable distances.

b. Ordinary. A set of rods of zinc or platinum of various forms fitting into the same insulating glass tubes.

3960. Small round Muscle-Chamber, with non-polarizable electrodes and registering lever. *Prof. Engelmann, Utrecht.*

Bottom, an ebonite disc 50 mm. diameter. Lid, a glass shade perforated at the top, consisting of two halves, one furnished with a handle.

Electrodes, two bent glass tubes; the vertical arm perforates the bottom of the chamber, and is at the top filled with clay impregnated with a solution of sulphate of zinc. Through the horizontal arm an amalgamated zinc rod soldered to a conducting wire is pressed into the clay. The openings of the tubes in the chamber are covered with salt clay. Between them the preparation (heart, gastrocnemius, etc.) is put, whose contractions (increase in thickness) can be registered by a lever attached by its axis to a lead wire, and resting on the preparation by means of a vertical pin passing through the central opening in the lid of the chamber. The whole movable on a stand.

3961. Gas Chamber for electro-physiological experiments particularly with living membranes. *Prof. Engelmann, Utrecht.*

The bottom of the chamber is an ebonite disc, diameter 13 cm., thickness 13 mm., resting on three small feet. Lid, a glass shade, height 12cm., diameter 11 cm., with a broad flat ground rim resting in a groove of the ebonite disc; through the perforated neck a thermometer can be introduced.

On the bottom of the chamber 6 binding screws, each separately in electrical connexion with corresponding binding screws on the outside of the chamber.

Inside the chamber between the binding screws, the object-support is placed, an ebonite plate furnished with:

1st. A central vertical slice to fix a horse-shoe cork frame upon which the animal membrane is spread.

2nd. On each side a glass pillar to fasten the electrodes.

To conduct the electric currents from the preparation small tubular non-polarizable electrodes are used; they are attached to lead wires and each connected by a very thin wire with one of the screws.

The other screws are to conduct electric currents, either to stimulate the object or to warm it by galvanism.

Two bent glass tubes, conducting through the bottom into the chamber, for the entrance and outlet of gases.

(Onderzoekingen gedaan in het physiologisch laboratorium der Utrechtsche Hoogeschool. Derde Reeks, II. 1873, p. 9, &c., Pl. I.)

3962. Isochronoscope. *Prof. Donders, Utrecht.*

A brass lever has at one extremity a registering spring and at the other extremity a peg. On pressing the lever down with the hand, the spring registers the instant at which the peg, touching the mercury, closes the circuit (white electrodes). At this instant, the physiological or psycho-physical effects of this currrent, in all kinds of experiments of irritation, are registered on the same cylinder. Underneath the lever are two electro-magnets. When the current (green electrodes) passes, the lever is pulled down. This current is used either to note certain periods of time, as seconds, on the cylinder, or, by means of a more equal closing of the circuit, to obtain greater equability of the irritating current than can be obtained by the hand. The equable breaking of the circuit is then secured by means of a spring under the lever.

3963. Apparatus for the **Determination** of the **Coefficient** of **Elasticity** of the **Living Muscles** in **Man.** (Compare Mansvelt, Elasticiteit der Spieren. 1860. Diss. inaug. Utrecht, 1863.) *Prof. Donders, Utrecht.*

A vertical wooden board, sliding up and down in a stand with foot, has on its upper side a little sliding beam, and on its surface two recesses, which are the centres of two graduated arcs. With the face directed towards the profile of the board, the operator leans with the shoulder against an extremity of the cross beam and softly presses the internal condyles of the humerus into one of the recesses. The humerus has a vertical position ; the forearm is stretched either horizontally at 0°, or above or below this position, and a weight suspended by a thread to a band round the wrist. On cutting this thread the forearm springs up, and the number of degrees is read off.

From different data the length of the muscle before and after the cutting of the thread and the action of the weight may be calculated, whence may be inferred the lengthening of certain muscles by definite weights at definite degrees of fatigue. One edge of the board is designed for the experiment with the left, the other for the experiment with the right, arm.

3964. The Double Spectacles, for the determination of refraction (Handbuch der Augenheilkunde von Saemisch und Graefe, III., p. 50). *Dr. Snellen, Utrecht.*

This is an opera-glass in the form of a pair of spectacles, consisting of a pair of negative glasses of one inch focal distance, and in front of these a pair of positive glasses of two inches focal distance. On changing the distance of the positive and negative glasses a hand is made to move on a disc furnished with a scale, which indicates the refraction of the system corresponding with the different degrees of sliding. To be had from R. Jung, optician, Heidelberg.

3965. Cylindrical Glasses (simple cylindrical, bi-cylindrical, and spherico-cylindrical) introduced by Donders (Astigmatismus en cylindrische glazen ; Utrecht, 1862). Metrical System by Roulot. *Prof. Donders, Utrecht.*

To detect and correct astigmatism. By turning a very weak cylindrical glass before the eye in a plane perpendicular to the visual line, it will be found that no eye is absolutely free from astigmatism.

3966. Test-types, for the determination of the acuteness of vision. Williams and Norgate, London. *Dr. Snellen, Utrecht.*

3972. Metallic Plates with two openings, **for Entoptic Observation.** (Anomalies, &c., p. 201.)

Prof. Donders, Utrecht.

To determine the position as to depth of entoptic objects (muscae volitantes, black spots, pearly spots, &c.) in the humours of the eye, by the method "à double vue." Those of one eye are projected in the visual field of the other, and the distance of the double images measured with a pair of compasses (sliding compasses).

3973. Optometer. To determine the relative range of accommodation. (On the anomalies of accommodation and refraction of the eye. New Sydenham Society, London, 1864, p. 115.)

Prof. Donders, Utrecht.

An oblong quadrangular board on a stand. The board possesses three grooves with scales, in which a wire optometer or a point can be moved. On the width of the board are two half-rings supporting the glasses, whose relative distance may be regulated by means of screws. Each ring is movable in a circular groove, the centres of the circles coinciding with the centres of motion of the eyes. The position of the eyes can be controlled by small microscopes fixed on the sides of the board, and remains secured by the cheeks resting against two wooden rods. By this contrivance, the distance between the glass and the eye remaining unchanged, the visual line may at any degree of convergence coincide with the axis of the glass. This instrument is used to determine the play of accommodation at every degree of convergence, *i.e.*, curves of the nearest and farthest points, as functions of the convergence (relative range of accommodation).

3974. Simple Phænophthalmotrope (large size for demonstration), to demonstrate movements of the eye according to the law of Listing, and the corresponding rotation. (Archiv für Ophthalmologie, XVI. 1, p. 154.) *Prof. Donders, Utrecht.*

In an outer fixed ring can be turned another ring, representing the principal plane of axes, containing all the axes round which the eye moves out of the primary into any secondary position. Before turning on the intended axis, we put the arms of the cross vertical and horizontal; after the rotation these arms indicate the position of the vertical and horizontal meridians of the eye.

3975. Compound Phænophthalmotrope (large size, for demonstration). *Prof. Donders, Utrecht.*

This instrument, as well as the simple phænophthalmotrope, No. 30, demonstrates the movements of the eye according to the law of Listing; but can moreover put the line of fixation in any direction by rotation round a vertical and a horizontal axis (Seitenwendung und Erhebung of Helmholtz). The cross then indicates a position of the meridians different from the position obtained by rotation round a single axis according to Listing's law; the difference is the so-called "wheel-rotation" of Helmholtz.

The same instruments (small size) for private study of the movements of the eyes; they enable us to compare the direction of the after-pictures with the direction of the cross in corresponding movements. (Compare: Onderzoekingen physiologisch laboratorium, Utrecht. Cl. S. ii. D. iii. bl. 119, and Archiv für Ophthalmologie B. xvi. S. 160.)

3976. Simple Phænophthalmot sonal use.

3977. Compound Phænophthal personal use.

3978. Snellen's Ophthalmotrop the movements to right and left of e Augenheilkunde von Saemisch und Gra

This instrument is intended to determine the left of each eye separately, and of both eyes wi

It consists principally of two bars rotating angle which can be read directly on a graduat bars.

The instrument is to be placed so that the p perpendicularly below the point of rotation of e

For this purpose, the plate upon which the backward to the right and to the left, indep which the head rests with the infra-orbital mar

The eye under examination is fixed upon th by one of the bars, and by moving to right a justed until the eye is in the middle of the Then the bar with the telescope is turned so examination is fixed again; if the point of rotat with the point of rotation of the instrument, th the middle of the field of view. By sliding forw appears again in the centre of the field of view the proper position with regard to the eye.

Now can be determined

1. The motility of each eye outward.
2. The limits of the lateral binocular vi
3. The convergence in straightforward lateral fixation
4. The degree of deviation in strabismus
5. The centre of motion of the eye.

3979. Ophthalmo-statometer, fo exorbital protrusion of the eye-ball.

Two rods, united by a cross rod, are supp margins of the orbit. From the cross rod a sma presses softly against the eye-ball covered by the eye-lid is to be subtracted from the readin the naked cornea may be read directly by mea of the rods. (Handbuch der Ophthalmologie p. 199.)

Manufactured by P. W. Hele, Utrecht

3980. Instrument for the determin of the **Head** and **Eye,** in varying direct Donders and Ritzmann. (Compare Ar XXI., 1, p. 131, 1875.)

A bent wooden rod has on one end a mouth piece, on the other an arc (with a sliding sight), movable round an axis passing through the point of rotation of the eye, which point is at the same time the centre of curvature of the arc.

Over the axis of the arc the eye is fixed on a point *a*, then, without moving the head, on a point *b*, to which the sight is made to correspond; now the eye is again fixed upon *a*, and with free movement upon *b*; from the required displacement of the sight we learn how much the head has shared in the movement. If after the free motion the plane of the arc should not pass through *b*, we make it pass through this point, and read off how many degrees we have had to turn.

3981. Apparatus for verifying the **Laws** of **Donders** and **Listing** (hitherto undescribed). *Prof. Donders, Utrecht.*

A bent wooden rod has on one end a mouth-piece and on the other a coloured strip, movable about an axis passing through the centre of movement of the eye.

After fixation in the direction of the axis, directing the eye upon one extremity of the strip, the after-picture is seen in the prolongation of the strip (Law of Listing) in whatever way the line of fixation reaches the extremity (Law of Donders).

From experiments made with lateral inclination of the head, we may learn how far the associated rotary motion interferes with the law of Listing.

3982. Reflecting Lens, with a mouthpiece **for autoscopy of the eye.** Donders (Holländische Beiträge zu den anatomischen und physiologischen Wissenschaften, Düsseldorf und Utrecht, 1864, p. 384; and Mulder, Archiv für Ophthalmologie, Bd. XXI., Abth. 1, 1875.) *Prof. Donders, Utrecht.*

Principally used to enable the eye, looking at a vessel of the conjunctiva, to observe its own rotations associated with lateral inclinations of the head. (The first application of the method consisting in uniting an instrument with the head, in order to secure the relative direction of the line of fixation.)

3983. Mouthpiece, with two vertical rods. Showing the rotations associated with lateral inclinations of the head and trunk, to be constantly equal for both eyes. *Prof. Donders, Utrecht.*

The rods parallel to the apparent vertical meridians, at a distance of 70 mm., produce parallel half images near each other. In all movements of the head the images remain parallel, thus showing the rotations associated with lateral inclinations of the head and trunk, to be constantly equal for both eyes.

3984. Rod, with graduated arc to determine the degree of lateral inclination of the head. *Prof. Donders, Utrecht.*

Seen with parallel visual lines, the rod shows double images of equal direction with the head (to be used in experiments of parallel relations, &c.)

3985. Apparatus for determining the rotary motion connected with temporary and permanent lateral inclination. Donders and Mulder (Archiv. für Ophthalmologie, XXI. Abth. 1, p. 68, 1875.) *Prof. Donders, Utrecht.*

This apparatus consists of (a) a head-holder, which, the head being fixed in the primary position, can revolve round a horizontal axis perpendicularly bisecting the basal line, and easily and quickly be secured in every position.

(b.) At a distance of some meters a round disc with horizontal light line of gas flames, situated in the principal plane of fixation, and possessing incisions on the rim for stretching diameters. After fixing the eye for some time on the middle of the light line, the gas is shut off, the head with the holder is turned and the latter secured, when the after-picture coincides with the stretched diameter. The difference between the inclination of the head and the inclination of the diameter is the rotary motion.

3986. Volkmann's Discs, united on one plate for the determination of the angle between meridians of apparent equal direction. The distance between the two axes must be equal to the distance of the parallel visual lines of the experimenter.

Professor Donders, Utrecht.

3987. Volkmann's Discs of Glass, facilitating parallel position of the lines of fixation by looking at a distance.

Professor Donders, Utrecht.

3988. Stereoscope with revolving mirrors for the determination of the angle between the meridians of apparent equal direction at different degrees of convergence.

Professor Donders, Utrecht.

3989. Isoscope, to determine the angle of the meridians of apparent vertical and apparent horizontal direction. (Onderzoekingen physiologisch laboratorium, Derde Reeks, III. 2., 45; and Archiv für Ophthalmologie, B. XXI. 3. S. 100.)

Prof. Donders, Utrecht.

The instrument consists of a head-holder and a frame-apparatus. In the holder (on the principle of Hering) as the head turns round the basal line as axis, the eyes retain their places. The frame-apparatus can rotate round the same axis, and consists of a fixed frame and two pairs of movable frames, one pair for nearly vertical, one pair for nearly horizontal threads.

One of the vertical or one of the horizontal threads may have a fixed position; the direction of the other is obtained by turning the frame, until both the threads viewed with the eye appear to be parallel. The angle between them in this position is read on the graduated arc with vernier.

This instrument is used to determine the angle of the meridians of apparent vertical and apparent horizontal direction, either separately or simultaneously, at any degree of inclination of the plane of fixation, and at any degree of convergence of the lines of fixation, either symmetrical or asymmetrical, and to investigate, at the same time, how lines or objects in the field of vision influence these angles.

3990. Perimeter Arc, with diagram of the plane of projection, for determining and registering the field of vision. (Handbuch der Augenheilkunde van Saemisch und Graefe, III. p. 57.)

Dr. Snellen, Utrecht.

A little below the centre of a movable metallic semicircle is a point for the infra-orbital margin to rest against; thus the eye under examination is kept as much as possible in the centre. Behind the arc a black board is

placed, which is marked with meridians from 10° to 10°, showing, as it were, the stretched arc with its divisions. The limits of the field of vision determined on the arc are mapped on the blackboard.

The scheme obtained represents clearly the limits of vision on each meridian.

To be had from D. B. Kagenaar, Utrecht. Its price is 22·50 f. (1*l.* 18*s.*)

3991. Cycloscope of Donders and Krüster, to show the direction of the meridians, the great circles, the direction circles, and the parallel circles of the field of vision. (Archiv für Ophthalmologie, B. xxii. 1876.) *Prof. Donders, Utrecht.*

This consists of a chair with head holder, and an arc with passing induction-sparks. The arc shows, by revolving round different axes, the directions of all meridians, of all great circles, of the direction circles of Helmholtz, and, by sliding up and down a stand, of parallel circles. When in a dark room, the position of the head being well secured, one eye (the other being covered) is placed in the centre of curvature of the arc and fixed, in the primary position, upon a mark, which owing to its being rubbed with phosphorus throws out a faint light; the induction sparks we may fancy to be distant stars, and determine the direction in which they appear. On the bearing of such investigations, compare Helmholtz, Physiologische Optik, §. 28, p. 550, and Krüster, *l. c.*

3992. Horopteroscope, for the determination of the line-horopter-plane, at different degrees of inclination of the plane of fixation and at different degrees of convergence.

Prof. Donders, Utrecht.

The horopter-plane (a quadrangular plate) can revolve round the basal line of the head fixed by the mouth-piece; the relative distance of the two horizontal stripes, seen with or without crossed visual lines, determines the convergence; the horopter-plane is now made to incline until the horizontal stripes have one direction, and then turned round a horizontal axis passing through these stripes until the two perpendiculars on the first stripes are also parallel. (By this contrivance we find the position for close work with the hands, which, according to Donders, has in course of time determined the angle between meridians of apparent equal direction.)

3993. Spark-Stereoscope, with coloured lenses, showing stereoscopic vision independent of movement of the eye. Archiv für Ophthalmologie, Band xiii. p. 33. *Prof. Donders, Utrecht.*

A box with two apertures for the eyes. A series of very small induction-sparks is used as object of fixation. Between two electrodes attached to the sliding lid of the box, we may cause a large spark to pass at different distances before and behind the object of fixation. In monocular vision we fail in recognising the place of the large spark with regard to the object of fixation; but in binocular vision, at the first spark we judge correctly. Between the apertures for the eyes are other electrodes. The spark passing between these last two electrodes is out of sight, but its two reflex images are seen on a coloured lens; one image is coloured the other not. In binocular vision, their position with regard to the object of fixation is soon distinguished; but without an object of fixation, many sparks are required for accurate estimation. In general such coloured lenses are very convenient for demonstration and mutual comparison of the reflex images of concave and convex surfaces.

3994. Photostereoscope, to determine the relative value of the second eye for binocular vision, constructed upon the principle of Hering. *Prof. Donders, Utrecht.*

in a little box suspended on a cross-bar between electrodes with knobs, which are to be moved so far apart that the passing electricity constitutes only one spark. In order to see or to hear the spark, a Leyden jar is inserted in the circuit; the shock is felt as unipolar conduction without an inserted Leyden jar.

On the stimulus being received, it is responded to by the hand moving a copper arm of a wooden cylinder with registering spring. By this contrivance, under similar objective and subjective conditions, the physiological time (the time between stimulation and response) can be determined alternately for impressions of vision, of hearing, and of touch at various places of the skin.

A dilemma may be put. Electrodes are applied right and left on the skin, and the horizontal arm of the wooden cylinder struck in corresponding direction. In a similar manner, by a conventional response, a decision may be made between red and white light. In both cases response may be forbidden for one colour or for stimulation on one side. Instead of responding with the hand, the voice may be used acting on the phonautograph, and the physiological time determined in both cases. On the spark passing in the box, and making transparent letters visible, the physiological time for recognising these letters may be registered and compared with the time for simple light perception, etc.

The second ring has only a small conducting plate, upon which, at the rotation of the cylinder, the constant current is closed and broken, after contact with the electrodes of the induction current has followed. Thus, by sliding this second ring, sooner or later after the first spark, a second is made to pass, perforating the chronoscopic line, and at the same time, either visible in the second compartment of the box, audible, or sensible at another part of the skin. So we learn the time between two impressions on the same sense, or on two different senses, which enables us to judge about the priority.

In order to prevent, under all circumstances, the sparks from passing from one ring to the other, a somewhat greater distance between the rings is desirable.

Professor Marey's Apparatus for observing and registering Physiological and Mechanical Phenomena.

3997. 1. Cardiac sounds for indicating the pressure in the cavities of the heart. A. Sound for the right heart. B. Sound for the left heart. C. Sound for showing negative pressures. D. Sphygmoscope. (The corresponding tracings are given in Plate I., 1–4.

2. Explorator for the heart of the rabbit. (Plates 2 and 2 quater.)

2A. Explorator for the human heart. (Plate II.)

3. Explorator for the pulse (sphygmograph of transmission). (Plate III.)

4. Explorator for the respiratory movements. (Plate IV.)

5. Myographic pincers.

5A. Myographic pincers, another pattern.

6. Explorator for the investigation of to-and-fro movements, such as those of locomotion (of the horse), and of flight (of birds). (Plate VI.)

...orator for determining the rapidity of the flow of fluids.
...orator for determining the changes in the size of the

...lorator for determining the changes in the size of the
...arts of the tortoise. (Plate 8 and 8 bis.)

9. Apparatus of "Donders" for verifying the correctness of tympana.

10. Myograph for transmission.

11. Myograph, direct, double.

12. Myograph, direct, single.

13. Myograph of the heart. (For these 3 apparatus, Plate 12 ...)

14. Explorator of the mov... s of liquids in an elastic tube. (... 14 and 14 bis.)

15. Explorator for investigating the pressure of the foot in ...an progression.

15A. }
15B. } " " " " feet of the horse.
15C. }

16. Apparatus for showing the action of muscular elasticity.

17. Tracing on paper transferred direct to wood.

18. Registering cylinder, with "Foucault" regulator, and rotatory hopper, by Marey.

19. Tympanum and lever recording instrument.

20. Hæmodromograph, by Chauveau.

21. Portable electric chronograph.

22. Tambours conjugués, for reproducing *movements at a* distance.

23. Pantograph of transmission, for reproducing movements at a distance.

7. For demonstrating the laws of vision:

   Large glass model of human eye; stereoscope and geometrical slides, to show effect of binocular vision.

8. Diagrams of—

   (*a.*) Shadow and penumbra.
   (*b.*) Lateral inversion of reflected image.
   (*c.*) Distance of image behind mirror.
   (*d.*) Refraction by prism.
   (*e.*) " " convex lens and formation of image.
   (*f.*) " " concave " " "
   (*g.*) The human eye.

   The foregoing set is contained in a strong case, 24 × 18 × 9 inches, with fittings for facilitating the employment of the apparatus.

Dr. Marey, Professor of the College of France, Paris.

XI.—DIAGRAMS, MODELS, PREPARATIONS, AND OTHER APPLIANCES FOR INSTRUCTION IN BIOLOGY.

3807. Photographs of Microscopic Objects on Glass.
(Dr. Maddox), J. H. How and Co.

3808. Recent Marine Mollusca. Typical collection, comprising 300 genera; to illustrate Woodward's "Manual of the Mollusca," and other works. *R. Damon.*

3809. Land and Fresh Water Mollusca. Typical collection, comprising 155 genera; to illustrate Woodward's "Manual of the Mollusca," and other works. *R. Damon.*

3810. British Marine Shells, illustrative of Dr. J. Gwyn Jeffreys's "British Conchology." 336 species. *R. Damon.*

3811. British Land and Fresh Water Shells, illustrative of Dr. J. Gwyn Jeffreys's "British Conchology." 122 species.
R. Damon.

3812. Skeletons. Two specimens of Manis or Pangolin, exhibiting a method of articulating skeletons, by which all the surfaces of the bones can be examined. Invented by Mr. James Flower, articulator to the Royal College of Surgeons.
Royal College of Surgeons of England.

In the larger specimen the parts of the skeleton are in their natural relation, but any portion which may be required for examination can be removed without disturbing the rest, as is shown in the smaller specimen, which is divided into various segments, the individual bones of which are united by flexible wires.

3813. Carbon Photographs of microscopic objects for projection by the lantern.
Professor D. Huizinga, Physiological Laboratory of the University of Groningen.

3815. Case containing twelve **Injected Preparations** by the celebrated Lieberkühn (born 1711, died 1756); each preparation is separately mounted in a brass magnifier with an ebony handle. *The Royal College of Surgeons of England.*

The object, which is opaque, is viewed with light concentrated upon it by means of a concave polished metal condenser (known as a "Lieberkühn"), and magnified by a simple lens adapted to a perforation in the centre of the condenser.

3816. Two small Cases with Lieberkühn's Preparations in microscopes.
Royal Museum at Cassel (Director, Dr. Pinder).

The two collections of *Lieberkühn* have been made in the earlier part of the 18th century. According to *Harting*, the Royal College of Surgeons of England possesses a similar one.

3816a. Microscopical Preparations. No. 1–289.

I. History of the development of the Cephalopoda.

II. Microscopical anatomy of the Tunicata.

III. Histology of the nervous system of the Vertebrata.

Dr. Michel Oussoff, Russia.

3816b. Microscopic Preparations.

Zoology.—Preparations of tissues in their normal, and in their morbid state.

Vegetative physiology.—Elementory organs, cells, vessels, composite organs, epidermis, stems, roots, organs of reproduction.

Medicinal substances.—Stems, roots, barks, seeds, salts used in pharmacy.

Alimentary products.—Flours, feculæ, prepared with the object of defining commercial adulterations.

Textile products.—Prepared with the object of defining commercial frauds. *Eugène Bourgogne, Paris.*

3818. Models exhibiting the **Anatomical Symptoms** of **Cattle Disease.** *A. Th. Ferhaar, Utrecht.*

No. 1.—Three cows' eyes:

A. A healthy eye, of which the sclerotic and the accessory eyelid are pale.

B. A healthy eye, in which the same parts are of a brown colour: this is considered as a distinctive mark that the animal is not liable to catch the disease.

C. The eye of a cow attacked by the cattle disease. The red colour of the above named parts may be noticed.

No. 2.—The extremity of the lower jaw and the inner surface of the lower lip of a cow attacked by the cattle disease. In these an irregular swelling and the difference of colour, as well as the excoriated and lacerated places on the gum, are to be noticed. A part of the same jaw seen inside, having the same symptoms.

No. 3.—The cartilaginous septum nasi of a cow that has died of the cattle disease, seen on the right side. The red colour and violent swelling of the mucous membrane and the great quantity of thick mucus are particularly remarkable; on the edge of the nostril an affection of the skin and dry crusts of mucus are to be noticed.

No. 4.—The right side of the larynx and a portion of the windpipe of a cow that has died of the cattle disease. The red colour and the swelling of the pyogenic membranes are to be seen.

No. 5.—A portion of the œsophagus (gullet) of a cow that died of the cattle disease. One part of the inner membrane is nearly healthy, the other very red and swollen.

No. 6.—The palate of a cow that has died of the cattle disease.

No. 7.—The end of the abomasum and the beginning of the small intestines of a cow that has died of the cattle disease. The violent swelling, the red colour, the small pyogenic cavities, and the black crusts of blood on the mucous membrane of the stomach are remarkable.

No. 8.—A piece of the small intestines of a cow that has died of the cattle disease, opened and seen inside. The red colour, and the swelling of the mucous membrane, in which Peyerian glands swollen and empty are seen.

No. 9.—A piece like No. 8. Several black spots may be noticed.

No. 10.—A piece like No. 8 and No. 9. Besides the swollen glands the difference of colour may be seen.

No. 11.—A piece like Nos. 8, 9, and No. 10. Here and there a difference of colour is apparent.

No. 12.—A piece like Nos. 8, 9, 10, and 11. The mucous membrane appears thinner and duller.

No. 13.—The end of the small intestines and the cæcum of a cow that has died of the cattle disease, opened and seen inside. The much-swollen folds, the redness of the mucous membrane, as well as the black spots, especially at the point of transition from the small intestines to the large, are remarkable.

No. 14.—The end of the rectum of a cow that has died of the cattle disease, opened and seen inside. The folds of a black colour, and the considerable swelling and redness of the mucous membrane are remarkable.

No. 15.—A piece of the skin of a cow that has died of the cattle disease, taken from the inner surface of the leg. Grey crusts covering the diseased parts of the skin, and between these the fissures in the true skin, are to be noticed.

3819. Skull of Sheep (*Ovis aries*). The bones have been disarticulated and mounted in segments, according to their morphological relations, so that each segment may be removed for lecture purposes. *E. T. Newton, Museum of Practical Geology.*

The following is the order in which the bones are grouped:—

BRAIN CASE.—1st Segment. Basioccipital and two exoccipitals ankylosed, supraoccipital.

2nd Segment. Basisphenoid and two alisphenoids ankylosed, and two parietals ankylosed.

3rd Segment. Presphenoid and two orbitosphenoids ankylosed, and two frontals.

NASAL REGION.—Mesethmoid, two superior and two middle turbinals and vomer, all ankylosed, and two nasals free.

AUDITORY REGION.—Right side. Squamosal, tympanic and periotic mass. (The periotic bones being ankylosed.)
Left side. Ditto ditto.

FACIAL REGION.—1. The two premaxillæ.
2. Right side. Maxilla, jugal, lachrymal, and inferior turbinal.
3. Left side. Ditto ditto.
4. Right side. Palatine and pterygoid.
5. Left side. Ditto ditto.

FIRST VISCERAL ARCH.—Right side. Ramus of lower jaw and malleus (latter, for convenience, mounted separately).
Left side. Ditto ditto.

SECOND VISCERAL ARCH.—The hyoid, consisting of basihyal, two ceratohyals, two epihyals, two stylohyals, and two tympanohyals. (One of the tympanohyals is left attached to the tympanic bone). The two thyrohyals belong to the third visceral arch, but are mounted here for convenience.

The incus and stapes of each side are mounted separately on account of their small size; but the former belongs to the second visceral arch, and the latter is most probably a part of the auditory capsules.

3820. Biological Specimens, six bottles.

Professor Rolleston, F.R.S., Oxford University Museum.

3820a. Collection of Entomological Preparations for the **Microscope,** comprising dissections of insects and whole insects, mounted in Canada balsam. *Frederic Enock.*

Some of these preparations are mounted in a deep cell, and by being treated in a peculiar manner their natural form is preserved, and the *internal* structure of muscles and tarcheæ seen in their natural positions.

3821. Objects exhibited by Professor Moser.

The geometrical and perspective drawings, I., II., and III., represent an apparatus for the determination of the products of the respiration and perspiration of animals. The apparatus is arranged at the I. R. Chemico-Agricultural Experimental Institution at Vienna, for experiments on horses, cattle, sheep, and pigs. The plan is that of Professor M. Pettenkofer, of Munich, excepting that for the aspiration of the air, which is the same as that adopted in a smaller apparatus by Professor C. Voit, of Munich. The parts are as follows:—

A, chamber for the reception of the animal during the experiment.

B, tube of tin, for the passage of the gaseous products from the chamber.

C, a vessel in which the gaseous products are saturated with watery vapour.

D, a gasometer in which the volume of the gases is determined.

E, tube through which the measured gases escape.

F, engine (hot air) which, by turning the revolving drum of the gasometer, aspirates the gases through the parts A, D, and, as a consequence, draws fresh air in through the openings in the back of A.

To ascertain the quantities of carbonic acid, aqueous vapour, and methan (marsh gas) evolved by the animal, the composition both of the gases passing from the chamber A through the tube B and of the fresh air is determined with regard to their contents of these substances, and the difference shows the quantities of the gases evolved.

For these examinations the apparatus shown on the table G is employed. Aspirating and forcing pumps (*c*, *c*, *c*,) which close with mercury, draw small quantities either of air from B through the tubes *a*, *a*,, or of fresh air through the tubes *b*, *b*, and force them through the absorption apparatus *d*, *d*, and *d*1, *d*1, or *d*2, *d*2, to the gasometers *e*, *e*, *e*, where they are measured.

The motion of the pumps is effected by the engine F by means of the mechanism *o*, *p*, *q*, *r*, *s*. To every absorption apparatus there appertain two pumps which alternately aspirate and force, and four valves with mercury joints (*f*, *f*, *f*...).

The carbonic acid is absorbed by a test solution of baryta in the tubes *d*, *d*, .. and *d*1, *d*1.

The aqueous vapour is determined in the flasks *d*2, *d*2, which contain pumice stone saturated with sulphuric acid.

The carburetted hydrogen is oxidated by passing over ignited oxide of copper. For this purpose a portion of the air to be analysed is drawn by the pumps through the tubes *g*, *g*, filled with oxide of copper, and placed upon a furnace H. The products of the oxidation, carbonic acid and water, are then conveyed to the absorption apparatus and gasometers.

The drawing IV. represents a similar apparatus, but of smaller dimensions, which also is employed at the I. R. Chemico-Agricultural Experimental Institution at Vienna. Its construction is in the main the same, excepting that the ventilation is effected by the exhausting fanner K. The motion of K

and of the pumps (*c*, *c*,) is effected by the mechanism L, which is worked either by a man or by a small water wheel. (The other signs on this drawing IV. correspond with those of the drawings I., II., III.)

The smaller apparatus is used for experiments with poultry, rabbits, and other small animals.

3822. Photographs of Microscopic Objects. Enlarged from negatives by Dr. Maddox, for illustration by means of the lantern. *James How & Co.*

3823. Mounted Preparation to show a method of putting up dried membranous specimens for museums.

Professor Struthers, Aberdeen University.

The glass jar is not essential. The wire loop displays and also protects the preparation, and the tube enables it to be turned round on the stand, or to be taken out and held up by the stem for demonstration. Curators of museums may remove the cover and examine the mounting. The specimen is a preparation of the human pyloric "valve."

3823a. Specimens of Linnæus's MS.

"Iter Dalekarlicum," a MS. journal of a tour made at the suggestion of Governor Reuterholm, in the year 1734, through the provinces of East and West Dalecarlia, by Linnæus himself, accompanied by several students from the University of Upsala, who were devoted to the study of natural history, each student undertaking to record daily his observations on the particular branch assigned to him.

The journal, which is chiefly in Swedish, and does not seem ever to have been published, is illustrated by pen and ink sketches, and accompanied by one engraved and two MS. maps of the district traversed.

SPECIMENS FROM LINNÆUS'S COLLECTIONS.

a. Zoological.

1. *Mya margaritifera.*

In his letter to Hallet, dated Upsal, Sept. 13, 1748, Linnæus writes, "At "length I have ascertained the manner in which pearls originate and grow "in shells,* and I am able to produce, in any mother-o'-pearl shell that "can be held in the hand, in the course of five or six years, a pearl *as large* "*as the seed* of common vetch."

2. *Testudo pusilla*, L., native of the Cape of Good Hope, both named in Linnæus's own hand.

3. *Scomber Chrysurus*, native of Carolina.

* "For this discovery the illustrious author was splendidly rewarded by "the States of the Kingdom."—*Haller*. Specimens of pearls so produced by art in the *Mya margaritifera* are in the Linnæan Cabinet.

"The shell appears to have been pierced by flexible wires, the ends of "which perhaps remain therein."—(Smith's Selection of the Correspondence of Linnæus, II , p. 428.)

In his Memoir of Linnæus, in Rees's Cyclopædia, Sir James Smith, after mentioning that his patent of nobility was confirmed by the Diet in 1762, goes on to state that that august body honoured him with a still more solid reward, upwards of 520*l.* sterling, for his discovery of the art of producing pearls in the river mussel by wounding the shells; but the practice does not seem to have been prosecuted to any great extent.

b. Botanical.

(All glued on paper, poisoned to protect them from insects, and named in Linnæus's own hand.)

1. *Linnæa borealis*, Gron. Named in honour of Linnæus, by his pupil Gronovius.
2. *Sibthorpia Europæa*, Linn.
3. *Browallia demissa*, Linn.
4. *Hebenstretia capitata*, Thunb.
5. *Erinus capensis*, Linn.
6. *Buchnera Asiatica*, Linn.
7. *Pedicularis tuberosa*, Linn.

DRIED SPECIMENS OF PLANTS FROM THE SOCIETY'S BRITISH HERBARIUM.

1. Ranunculus, 17 sheets.
2. Dentaria, 3 sheets.
3. Matthiola, 2 sheets.
4. Linum.
5. Fragaria, 4 sheets.
6. Oxalis, 2 sheets. *The Linnæan Society.*

3823b. Specimens of the Linnæan Society's Publications. *The Linnæan Society.*

1. TRANSACTIONS. 4to. (*Illustrated.*)
   Vol. 19, Part 2, containing papers by—
      Hope on rare and beautiful insects from Silhet.
      Blackwall on British Spiders.
      Queckett on Ergot.
      Forbes on the *Ophiurida* of the E. Mediterranean, &c.
   Vol. 22, Part 4, containing—
      Hooker on the Pitchers of *Nepenthes*, with account of new species from Borneo.
      Hooker on new *Balanophoreæ*.
      Bentham on *Henriquezia*.
      Seemann on *Camellia* and *Thea*.
      Cobbold on new *Entozoa*, &c.
   Vol. 24, Part 1.
      Hooker on *Welwitschia*.
   Vol. 26, Part 4.
      Williamson and *Carruthers* on Fossil *Cycadeæ*.
   Vol. 27, Part 1.
      Welwitsch. Sertum Angolense: S. Stirpium . . . in itinere per Angolam et Benguelam observ. descriptio, *Iconibus illustrata.*
   Vol. 29, Part 1.
      Col. Grant. Botany of the Speke and Grant expedition from Zanzibar to Egypt.

TRANSACTIONS. SECOND SERIES; in which the two sections, *Zoology* or *Botany*, are published separately.

Zoology.
   Vol. 1, Part 1, containing—
      Willemoes Suhm, on Atlantic Crustacea from the "Challenger" Expedition.

Parker on the Morphology of the skull in the Woodpecker, &c.

Allman on *Stephanoscyphus mirabilis;* the type of a new order of Hydrozoa.

Botany, Vol. 1, Part 1.

Miers on *Napoleona*, *Omphalocarpum*, and *Asteranthos*.

Miers on *Auxemmeæ*.

TRANSACTIONS. Specimens of papers, from the later volumes, printed off for separate sale.

Botanical.

1. *Welwitsch* and *Currey*. Fungi Angolenses (from Vol. 26, Part 1).
2. *Scott*. Tree Ferns of British Sikkim (from Vol. 30, Part 1).

Zoological.

3. *Trimen*. Mimetic Analogies among African Butterflies (from Vol. 26, Part 3).
4. *Murée* on the three-banded Armadillo (Vol. 30, Part 1).

2. JOURNAL, 8vo. The two sections, *Zoology* and *Botany*, published separately. The papers illustrated when necessary.

Zoology, Nos. 60–62, containing—

Allman, on new genera and species of *Hydroida*.

Cobbold on the large Human Fluke (*Distoma Crassum*), &c.

Botany.

No. 74. *Berkeley* and *Broome*. Fungi of Ceylon.

No. 82. Contribution to the Botany of H.M.S. "Challenger."

Supplement to Vol. 5.

Anderson. Florula Adenensis; account of the flowering plants hitherto found at Aden.

3824. Entire Plant and Flowering Branches of *Welwitschia mirabilis*, Hook, fil. Discovered by Dr. Welwitsch, in South-west Africa, in 1859. *Museum, Royal Gardens, Kew.*

This plant is the subject of a memoir by J. D. Hooker, M.D., P.R.S., in the Transactions of the Linnæan Society, Vol. XXIV.

3825. Series of Fruits illustrating the variety of form in the **Dalbergieæ,** a tribe of **Leguminosæ.**
Museum, Royal Gardens, Kew.

Described by George Bentham, Esq., F.R.S., &c., in Supplement to Vol. IV. of the Journal of the Linnæan Society.

3826. Fruits illustrating the **Rubiaceæ,** a very large order of tropical trees and shrubs. *Museum, Royal Gardens, Kew.*

The genera of these have been revised and published in Part I., Vol. II. of the "Genera Plantarum," by G. Bentham, F.R.S., and J. D. Hooker, M.D., P.R.S.

3827. Series of Fruits, showing the variation in form and size of the different species of **Eucalyptus,** a genus of shrubs or trees, commonly known as gum trees, almost exclusively confined to Australia. *Museum, Royal Gardens, Kew.*

The species have been described by George Bentham, Esq., F.R.S., in Vol. III. of his "Flora Australiensis."

3828. Fruits and Seeds of plants belonging to the natural order **Bignoniaceæ,** a family of twining or climbing plants or trees. Found chiefly in the tropics.
Museum, Royal Gardens, Kew.

The lacteal system has been injected with Berlin blue by the insertion of the point of a syringe into the lacunar system. The injection is seen to have passed into some of the adjacent mesenteric glands. Prepared by Professor Rolleston.

3835. One Longitudinal and two Transverse Sections of the Appendix Vermiformis of Rabbit (*Lepus cuniculus*).
The Anatomical Department, University Museum, Oxford.

The blood vessels have been minutely injected with carmine and the lacteals with Berlin blue. Prepared by Mr. Robertson.

3836. The Right Half of the Skull of a Sturgeon (*Acipenser sturio*), macerated, and mounted in the ordinary way. Prepared by Mr. Robertson.
The Anatomical Department, University Museum, Oxford.

3837. Left Half of the Skull of a Sturgeon (*Acipenser sturio*), stained to show the cartilaginous cranium.
The Anatomical Department, University Museum, Oxford.

This preparation was placed for several hours in staining fluid, which has tinted the cartilaginous cranium whilst leaving the bony elements with their natural white colour. Prepared by Mr. Robertson.

3838. Skull of a Sturgeon (*Acipenser sturio*), stained to show the cartilages.
The Anatomical Department, University Museum, Oxford.

The opercular bones of both sides have been removed, also the shoulder girdle, parietal and frontal bones of the left side, to show the cartilaginous cranium. Prepared by Mr. Robertson.

3839. Set of Wax Models, to illustrate the **Development** of the **Trout** (*Trutta fario*), containing 21 preparations, including 7 sections. The preparations can be viewed by transmitted light. Magnified 30 diameters. *Dr. A. Ziegler, Freiburg i. B.*

This series is the latest work of the exhibitor, and the 21st series of his scientific wax preparations for illustrating biological facts, and particularly the changes during development. These wax models are copied from nature, and enlarged so as to be useful for teaching purposes. Compare the accompanying prospectus and account of physiological preparations in wax for the use of English readers.

A full account of the development of the trout's egg will be found in Zeitschrift f. wiss. Zool., Vol. 22, Part IV., Plates 32 and 33, and Vol. 23, Part I., plates, 1, 2, 3, and 4, in papers by Professor Oellacher of Innsbruck.

3839a. Collection of **Preparations** for the **Study** of the **Embryology** of the **Sterlet** (*Acipenser ruthenus*), from the segmentation of the egg to the one year old fish.
Ph. Owsiannikow, University of St. Petersburg.

The first artificial fecundation of the eggs of this fish was made by M. Ph. Owsiannikow, in the year 1869, at Simbirsk on the Wolga, and in the same year a small quantity was brought by him to St. Petersburg. The exhibited embryos presented have grown up in an aquarium in the study room of M. Owsiannikow, who wishes to present them to the South Kensington Museum.

3839b. Preparations on the **Embryology** of the **Sterlet** (*Acipenser ruthenus*).

The time is fixed approximately, as at an early stage temperature and quantity of food have a great influence on the development. No. 1. First day, the hole of Rusconii forms the half of the egg. No. 2. Second day, morning, the hole of Rusconii is smaller. No. 3. Second day, evening, the hole of Rusconii is very small. No. 4. Fourth day, the hole of Rusconii has disappeared. No. 5 Fifth day. No. 6. Sixth day. No. 7. Seventh day. No. 8. The third and fifth days after their coming out from the egg. No. 9 About a week after their coming out. Nos. 10 11, 12, 13. From two to four weeks. No. 14. About six weeks; bastard of an [illegible]cipenser Güldenstaedtii (soft roe), and of an Acipenser ruthenus (ha[illegible]). No. 15. About two months. No. 16. About a year; reared in an [illegible]m. If there is plenty of food the fish can attain about double this size [illegible] same period.

3840. Original Cast of the [illegible]k of a boy, the thorax opened to show the natural position of th[illegible]eart after removing the lungs.
Steger and Honikel, [illegible]natomical Institute, Leipzig.

3841. Cast, with the **Abdominal Cavity** opened to show the natural form and position of the stomach, liver, and kidneys, &c.
Steger and Honikel, Anatomical Institute, Leipzig.

3842. Several Small Original Casts.
Steger and Honikel, Anatomical Institute, Leipzig.

3843. Histological Photographs.
Steger and Honikel, Anatomical Institute, Leipzig.

3844. Photographs to illustrate the **Changes** during **Development.**
Steger and Honikel, Anatomical Institute, Leipzig.

3845. 25 Photographs on Glass, for the magic lantern, for instruction in physiology (anatomy, physiology, biology, and development). *Dr. S. Th. Stein, Frankfort.*

These slides have been photographed from nature.

3846. Three Large Diagrams. *Dr. S. Th. Stein, Frankfort.*

These contain—
1. 35 physiological photographs.
2. The application of photography to physiology and medicine.
3. Thermophotography. (The whole taken from nature.)

3847. Diagrams, for botanical teaching, by L. Kny. 1–20. *Prof. Kny, Berlin.*

These diagrams are published by Wigand, Kempel, & Co., Berlin.

3848. Collections, for botanical teaching (in portfolio).
Prof. Kny, Berlin.

3849. Model of the Mechanism of the Accommodation of the Eye. *Prof. Beetz, Munich.*

This model is made from a design of Dr Beetz, and is explained by a drawing and description which accompany the apparatus.

3850. Three Wall Charts, with representations of **the Technical Geography of Plants.**

Prof. Jessen, Eldena, in Pomerania.

3851. Apparatus for representing the mechanical principle of the **Circulation** of **Sap** in **Cells.** Rough model.

Prof. Jessen, Eldena, in Pomerania.

3852. Plan of the **Institute of Vegetable Physiology of the University of Breslau,** with an account of its arrangements for instruction in the biology of plants.

Prof. Dr. F. Cohn, of the Institute of Vegetable Physiology in the University of Breslau.

The Institute of Vegetable Physiology in the University of Breslau was founded in the year 1866, and was intended (*a*) for experiments for the elucidation of the biology of plants, also for preparing all kinds of demonstrations for the lectures of its director, Professor Ferdinand Cohn, and to found for this purpose collections of apparatus, models, normal and pathological plant forms, herbaria, &c.; (*b*) to make the students, by means of courses of instruction on histology, familiar with the use of the microscope for phytobiological researches, and to afford them, by means of a collection of microscopical preparations, rich material for observation ; (*c*) to secure for original researches on the biology of plants the necessary rooms, instruments, and other assistance, as well as direction, and to publish the same as far as possible in the scientific publication of the institute, "Beiträge zur Biologie der Pflanzen ; Breslau, Verlag von Max Müller."

3853. Six Models, prepared by A. Lohmeyer, and presented to the collection of botanical models in the Phytophysiological Institute.

3854a. Vaucheria sessilis, development of the Sexual Organs.

3855b. Vaucheria sessilis, development of the Zoospores.

3856c. Eurotium aspergillus, development.

3857d. Models of Antherozoids.

3858e. Models of Zoospores.

3859f. Cypripedium Calceolus, model of the flower.

Prof. Dr. F. Cohn, of the Institute of Vegetable Physiology in the University of Breslau.

M. A. Lohmeyer prepared, during the years 1862–67, by the suggestion and under the direction of Professor F. Cohn, an extensive collection of botanical models comprising more than 350 specimens, the first and most complete of its kind which illustrates the structure of flowers and fruits of the phanerogamous families of plants, with especial attention to officinal plants and the development of the cryptogams. Out of this sprang the collection of botanical models made for sale by Brendel, and exhibited in his name.

3860. Glazed Frame, w
biological preparations and dr
(*Æcidium* Berberidis, Puccin
Dr. F. Cohn, of the I
the University of B

For lecture-demonstrations of he
rations, and collections of microsc
elucidate the diseases, &c. of plants
are in common use at the Institute
well adapted.

3861. 12 Botanical M

3862. 5 Botanical Mo

3863. 5 Botanical Mo

3864. 45 Models of I

67 botanical models, constructe
cultivated and wild plants, and th
1. Cultivated mono- and dicoty
ferm, Lineæ, Leguminosæ,
2. Fruit trees of the families
and Amygdaleæ
3. [illegible] from the fam
[illegible] and Cupuliferæ
4. Models of the inflorescence
[illegible] and [illegible]
[illegible] which
[illegible] together with ca
[illegible]

3865. Six Models of I

3866. Twelve Types
[illegible] system of
[illegible]

3867. Model of a Hu
[illegible]

This model has been moulded by the exhibitor accurately from nature, by 13 sections in successive planes through a firmly frozen leg. The advantages of such models for teaching, in lieu of the imperfect representations which have hitherto been used, are self-evident.

Models of other parts of the body similar to this have already been taken in hand by the exhibitor.

3868. Section of Head.

Rammé and Sodtmann, Hamburg.

By these anatomical models in papier mâché, the exhibitors intend to give a general insight into the structure of the human body to scholars and intelligent people. The aim of the exhibitors has been to combine accuracy with the greatest possible cheapness and durability.

Some of the models are taken from drawings by Dr. Simon, and some from those by Dr. Dehn.

3869. Head, with Muscles.

Rammé and Sodtmann, Hamburg.

3870. Model of the Ear enlarged, without muscles.

Rammé and Sodtmann, Hamburg.

3871. Eye enlarged. Perpendicular section.

Rammé and Sodtmann, Hamburg.

3872. Larynx, &c., natural size.

Rammé and Sodtmann, Hamburg.

3873. Lung. Perpendicular section.

Rammé and Sodtmann, Hamburg.

3874. Larynx and Lungs, in separable parts.

Rammé and Sodtmann, Hamburg.

3875. Model of Thorax, in separable parts.

Rammé and Sodtmann, Hamburg.

3876. Digestive Apparatus.

Rammé and Sodtmann, Hamburg.

3877. Perpendicular Section of Skin.

Rammé and Sodtmann, Hamburg.

3878. Biological Preparations for teaching zoology :—

1. Sphegidæ. Family of the carnivorous wasps, showing the rapacious manner of life and dwelling, with their victims.
2. Megachile betulina, a bee which cuts off a portion of birch leaf, showing its dwelling, with the piece of the leaf bitten off.
3. Bombus lapidarius, the mason bee, with construction of comb.
4. Myrmecoleon formicarius, the antlion, its funnel shaped-pit, larvæ, cocoons, &c.
5. Locusta viridissima, deposition of eggs and development.
6. Insects in amber, and their origin.

Prof. Dr. H. Landois, Münster, in Westphalia.

The preparations which have been sent are intended as specimens fo zoological instruction in the higher class educational establishments. They can be continually renewed by any teacher, and are not liable to destructio and will raise the standard of the objects concerned in teaching. They attracted the notice of the judges in the Vienna Exhibition, and gained medal as a mark of merit.

These and the following preparations were constructed for the exhibitor by Rudolph Roch, of Munich, manufacturer of anatomical preparations.

3878a. Two Prepar... Heads of children.
Ph. Ow... *o, University of St. Petersburg*

These preparations are take... Anatomic Museum of the Academ of Science at St. Petersburg ... te bought by the Emperor Peter th Great, in the year 1717, from ... inent anatomist of Holland, Ruysch (1638–1731), with his whole exo ... ollection.

The lessons of anatomy, the ner... system especially, must be demon strated by preparations. Most of th... preparations in spirit cannot be long preserved. The preparations of Ruy..., though very old, are extremely wel preserved. The collection of p... tions of Ruysch at the Museum o Anatomy of the Academy of Sci... Petersburg is unique in Europe.

3879. Horizontal ... **of the Eye-ball** through it meridian in a child six months old.
Anatomical Institute, Erlangen (Prof. Dr. T. Gerlach)

3880. Horizontal Section of the Tympanic Cavity an the cochlea of a child 10 months old.
Anatomical Institute, Erlangen (Prof. Dr. T. Gerlach)

3881. Frontal Section of the Head of a Child six month old through the cavities of the pharynx and mouth.
Anatomical Institute, Erlangen (Prof. Dr. T. Gerlach)

3882. Median Sagittal Section through the Head of a Child four months old.
Anatomical Institute, Erlangen (Prof. Dr. T. Gerlach)

3883. Lateral Sagittal Section through the Head of a Child four months old.
Anatomical Institute, Erlangen (Prof. Dr. T. Gerlach)

3884. Horizontal Section through the Neck of a Chil six months old.
Anatomical Institute, Erlangen (Prof. Dr. T. Gerlach)

3885. Horizontal Section through the Neck of the same Child somewhat deeper.
Anatomical Institute, Erlangen (Prof. Dr. T. Gerlach)

3886. Three Longitudinal Sections through the Heart of a Child 32 days old.
Anatomical Institute, Erlangen (Prof. Dr. T. Gerlach)

3887. Two Sections through the Larynx of a Child six months old.
Anatomical Institute, Erlangen (Prof. Dr. T. Gerlach).

3888. Two Sections, one longitudinal, one transverse, **through the Testicle of an Adult.**

Anatomical Institute, Erlangen (Prof. Dr. T. Gerlach).

3889. Median Longitudinal Section through the Uterus of a virgin 20 years old.

Anatomical Institute, Erlangen (Prof. Dr. T. Gerlach).

3890. Cross Section through the Arm of a Child six months old in the upper third.

Anatomical Institute, Erlangen (Prof. Dr. T. Gerlach).

3891. Cross Section of the Fore-arm of a Child six months old in the upper third.

Anatomical Institute, Erlangen (Prof. Dr. T. Gerlach).

3892. Cross Section of the Fore-arm of a Child six months old in the lower third (a glycerine preparation).

Anatomical Institute, Erlangen (Prof. Dr. T. Gerlach).

All these sections were prepared for the exhibitor for the purpose of demonstrating to a large audience, by means of the magic lantern (sciopticon), certain anatomical features, especially with regard to their topographical relations.

3893. Models of the Blood Corpuscles, for illustrating their form and size. (Magnified 5,000 times.)

Prof. Dr. H. Wolcker, Halle an der Saale.

3894. Model of the Bones of the Arm of Man, for demonstrating supination and pronation. Also an osteological preparation to which the bone of the fore-arm is attached by a steel wire. *Prof. Dr. H. Wolcker, Halle an der Saale.*

3895. Orchitis interstitialis.

Pietro Toninetti Pathological Institute, Berlin (Director, Prof. Dr. Virchow).

By means of this fluid, discovered by the exhibitor, the objects were kept perfectly fresh, and when prepared in the dry way by the exhibitor retained their fresh appearance.

3896. Normal Heart.

Pietro Toninetti Pathological Institute, Berlin (Director, Prof. Dr. Virchow).

3897. Lipoma subcutaneum.

Pietro Toninetti Pathological Institute, Berlin (Director, Prof. Dr. Virchow).

3898. Glioma cerebri.

Pietro Toninetti Pathological Institute, Berlin (Director, Prof. Dr. Virchow).

3899. Slaty discolouration of the mucous membrane of the large intestine.

Pietro Toninetti Pathological Institute, Berlin (Director, Prof. Dr. Virchow).

3900. Two Kidneys.

Pietro Toninetti Pathological Institute, Berlin (Director, Prof. Dr. Virchow).

3901. Two Normal Brains.

Pietro Toninetti Pathol ical Institute, Berlin (Director, Prof. Dr. Virchow).

3902. Bullock's Heart and Lungs.

Pietro Toninetti Pathological Institute, Berlin (Director Prof. Dr. Virchow).

3903. Histological Preparations for Teaching.

C. Rodig, Hamburg

I. Collection of 150 drug preparations, in accordance with the pharma ceutical atlas of Professor Berg, adapted for pharmaceutical instruc tion.
II. Sixty anatomical plant preparations for teaching botany.
III. Algæ, fungi, and mosses.
IV Cereals in sections for agricultural teaching.

3904. Sketch of an apparatus for investigating the **Influenc of Temperature** on the life of **Plants** and **Animals.**

Dr. W. Velten, Physiologist, I. R. Station for Experimen relating to Forests, Vienna.

The apparatus consists of a box of zinc, with double partitions, the upp and sides perpendicular thereto being replaced by parallel glass plates. T space between the partitions must be filled with fluids, while that in the cent is destined for the objects to be experimented on. The whole is surround by a wooden cover suited to receive a refrigerator. The box is heated fr below, and the temperature remains constant by means of a thermo-regula brought into connexion with the apparatus. At the sides are openings i which the hands should be placed, when encased in india-rubber gloves on in order to work without great change of temperature in the apparatus its By means of the same apparatus the influence of various coloured lig can be determined as well as that of gas, &c. at different degrees of te perature.

3904a. Skeleton of a Dog, disarticulated and mounted such a manner that every bone can be separately removed for e mination.

Prof. Huxley, F.R

3904b. Typical Parts of the Skeletons of a Cat, Duck, and a Codfish, disarticulated and mounted, to show chief modifications of the vertebrate endoskeleton.

Prof. Huxley, F.R

:. **Series of Fifteen Dissections,** illustrating the of the edible **Frog** (Rana esculenta).

Prof. Huxley, F.R.S.

l. **Series of Sixteen Diagrams,** illustrating the of the **Frog.** *Prof. Huxley, F.R.S.*

:. **The Exoskeleton of the Common Lobster,** dis-d and mounted. *Prof. Huxley, F.R.S.*

Botanical Class Diagrams, used by the Professor of Royal College of Science. Diagrams of Clasterium and ı; also of Cycas circinalis, illustrating drawings used in ical class in the Royal College of Science.

W. R. M'Nab, M.D.

Models of Monocotyledonous Embryos (8), pre- Dr. Ziegler, of Freiburg, in Breisgau, part of a set of .els used in the botanical class in the Royal College of

W. R. M'Nab, M.D.

Models of the flowers of Monocotyledonous and Dico-ıs plants; part of a set of models prepared by Robert in Breslau, used in the botanical class in the Royal f Science. *W. R. M'Nab, M.D.*

Diagram of the Myxastrum Radians, a non-nucleated ı feeding on Diatoms.

Professor A. Leith Adams, F.R.S.

Diagrams of the Eucecryphalus Schulzei and Helios-:rmis. *Professor A. Leith Adams, F.R.S.*

ve are two forms of radiolaria, showing their siliceous skeletons, .loform bodies of a bright yellow colour, containing starch. The d pseudopodia with granules are also represented.

Case of Specimens, illustrating the **Domination 'lant over another** in the mixed herbage of grass land, influence of different manures, each applied year after ıe same plot. *John Bennet Lawes.*

ıeriments were made in Mr. Lawes' park, at Rothamsted, near , commencing in 1856, at which time the character of the herbage :ntly pretty uniform over all the plots, and there were 50 species owing together. There are about 20 experimental plots, from a half an acre each; two being left continuously without manure, ɔf the others receiving its own special manure year after year. ɜ varied treatment, changes in the *flora*, so to speak, became ren in the first years of the experiments; and three times since nencement, at intervals of five years, namely, in 1862, 1867, and ·efully averaged sample of the produce of each plot has been taken .ted to careful botanical separation, and the per-centage by weight :cies in the mixed herbage determined. Partial separations have

also been made in other years. The specimens exhibited in the case show the botanical composition of the herbage on 12 selected plots, in the 17th season of the experiments, 1872; and the quantities represent the relative proportion by weight in which each species was found in the mixed produce of the plots.

The mean produce of hay per acre per annum has ranged on the different plots from about 23 cwts. without manure, to about 64 cwts. on the plot most heavily manured.

The number of species found has generally been about 50 on the unmanured plots, and has been reduced to an average of only 20, and has sometimes been less, on the most heavily manured plots.

Species belonging to the order *Graminaceæ* have, on the average, contributed about 62 per cent. of the weight of the mixed herbage grown without manure, about 55 per cent. of that grown by purely mineral manures (that is, without nitrogen), and about 93 per cent. of that grown by the same mineral manures with a large quantity of ammoniacal salts in addition.

Species of the order *Leguminosæ* have, on the average, contributed about 8 per cent. of the produce without ma[illegible]ure, about 26 per cent. of that with purely mineral manures, and less than [illegible]01 per cent. of that with the mixture of the mineral manures and a large [illegible]ity of ammoniacal salts.

Species belonging to various oth[illegible]rs have, on the average, contributed about 30 per cent. of the produce [illegible] manure, about 19 per cent. of that with purely mineral manures, and only about 7 per cent. of that with the mixture of the mineral manures and a large amount of ammoniacal salts.

Not only the amount of produce, but the number and description of species developed, have varied very greatly between the extremes here quoted, according to the particular character or combination of manure employed, as is strikingly illustrated by the arrangement of the specimens in the case.

3910a. Photographs under glass, for demonstrating the consequences of exterior damages to trees, the influence of cold on trees, and modes of protection of trees.

Royal Botanical Garden and Museum of the University at Breslau (Prof. Dr. H. R. Göppert).

3911. E. J. Spitta's working Model of the larynx.

Thomas Hawksley.

3912. 106 Original Water-Colour Drawings, by Wolf, illustrating the new and rare animals exhibited in the Society's Gardens. *The Zoological Society of London.*

(Uprights.)

1. Orang-Outang - - - *Simia satyrus.*
2. Chimpanzee - - - *Troglodytes niger.*
3. Hoolock Gibbon - - *Hylobates hoolock.*

(Longs.)

4. Ashy-black Ape - - - *Macacus ocreatus.*
5. Black-fronted Lemur - - *Lemur nigrifrons.*
6. Lioness and Young - - - *Felis leo.*
7. Painted Ocelot - - - *Felis picta.*
8. Ocelot - - - - *Felis pardalis.*
9. Ocelot - - - - *Felis pardalis.*
10. Egyptian Cat - - - *Felis chaus.*

11. Leopards - - - -	*Felis leopardis.*
12. Viverrine Cat - - -	*Felis viverrina.*
13. Canadian Lynx - - -	*Felis canadensis.*
14. Serval - - - -	*Felis serval.*
15. Caracal - - - -	*Felis caracal.*
16. Caracal - - - -	*Felis caracal.*
17. Eyra - - - -	*Felis eyra.*
18. Cheetah - - - -	*Felis jubata.*
19. Indian Civet - - -	*Viverricula indica.*
20. Ratels - - - -	*Mellivora capensis & M. indica.*
21. American Skunk - - -	*Mephitis mephitica.*
22. Fennec Fox - - - -	*Canis cerdo.*
23. Azara's Fox - - - -	*Canis azaræ.*
24. Bassaris - - - -	*Bassaris astuta.*
25. African Elephants - - -	*Elephas africanus.*
26. Walrus - - - -	*Trichechus rosmarus.*
27. Southern Sea-lion - - -	*Otaria jubata.*
28. African Rhinoceros - - -	*Rhinoceros bicornis.*
29. Andaman Pig - - -	*Sus andamanensis.*
30. Red Potamochere - - -	*Potamochærus africanus.*
31. Bosch-Vark - - - -	*Potamochærus penicillatus.*
32. Collared Peccary - - -	*Dicotyles torquatus.*
33. Hippopotamus - - -	*Hippopotamus amphibius.*
34. Hippopotamus - - -	*Hippopotamus amphibius.*
35. Panjaub Sheep - - -	*Ovis cycloceros.*
36. Thar Goat - - - -	*Capra jemlaica.*
37. Persian Gazelle - - -	*Gazella subgutturosa.*
38. Eland (young) - - -	*Oreas canna.*
39. Chinese Tailed Deer - -	*Cervus davidianus.*
40. Mantchurian Deer - - -	*Cervus mantchuricus.*
41. Formosan Deer - - -	*Cervus pseudaxis.*
42. White-tailed Deer - - -	*Cervus leucurus.*
43. Japanese Deer - - -	*Cervus sika.*
44. Rusa Deer - - -	*Cervus rusa.*
45. Swinhoe's Deer - - -	*Cervus swinhoii.*
46. Persian Deer - - -	*Cervus maral.*
47. Pudu Deer - - - -	*Cervus pudu.*
48. Large-eared Brocket - -	*Cervus auritus.*
49. Alpacas - - - -	*Auchenia pacos.*
50. Great Ant-eater - - -	*Myrmecophaga jubata.*
51. Great Ant-eater - - -	*Myrmecophaga jubata.*
52. Two-toed Sloth - - -	*Cholopus didactylus.*
53. Thylasine - - - -	*Thylacinus cynocephalus.*
54. Broad-fronted Wombat - -	*Phascolomys latifrons.*
55. Common Wombat - - -	*Phascolomys wombat.*
56. Mantell's Apteryx - - -	*Apteryx mantelli.*
57. Mooruk - - - -	*Casuarius bennetti.*
58. Rhea (young) - - -	*Rhea americana.*
59. Painted Spur-fowl - - -	*Galloperdix lunulosa.*
60. Caspian Snow Partridge - -	*Tetraogallus caspius.*
61. Sœmmerring's Pheasant - -	*Phasianus sœmmerringi.*
62. Ring-necked Pheasant - -	*Phasianus torquatus.*
63. Japanese Pheasant - - -	*Phasianus versicolor.*
64. Horned Tragopan - - -	*Ceriornis satyra.*
65. Rufous-tailed Pheasant - -	*Euplocamus erythrophthalmus.*
66. Vieillot's Fire-back - - -	*Euplocamus vielloti.*

67. Swinhoe's Fire-back	*Euplocamus swinhoii.*
68. Horsfield's Kaleege	*Euplocamus horsfieldi.*
69. Siamese Pheasant	*Euplocamus prælatus.*
70. Lineated Pheasant	*Euplocamus lineatus.*
71. Weka Rails	*Ocydromus australis.*
72. Brush Turkey	*Talegalla lathami.*
73. Black-necked Swan	*Cygnus nigricollis.*
74. White-winged Casarca	*Casarca leucoptera.*
75. Upland Goose	*Chloëphaga magellanica.*
76. Ashy-headed Goose	*Chloëphaga poliocephala.*
77. Indian Tantalus	*Tantalus leucocephalus.*
78. African Tantalus	*Tantalus ibis.*
79. Shoebill	*Balæniceps rex.*
80. Egrets	*Ardea candidissima & A. garzetta.*
81. Mantchurian Crane	*Grus montignesia.*
82. Kagu	*Rhinochetus jubatus.*
83. Angola Vulture	*Gypohierax angolensis.*
84. Bataleur Eagle	*Helotarsus ecaudatus.*
85. Schlegel's Clotho	*Clotho rhinoceros.*
86. Clotho	*Clotho nasicornis.*

(Uprights.)

87. Stanger's Monkey	*Cercopithecus stangeri.*
88. Ocelot	*Felis pardalis.*
89. Ocelot	*Felis pardalis.*
90. Clouded Tiger	*Felis macrocelis*
91. Norwegian Lynx	*Felis lynx.*
92 Binturong	*Arctictis binturong*
93. Syrian Bear	*Ursus syriacus.*
94. Aoudad	*Ovis tragelaphus.*
95. Markhoor	*Capra megaceros.*
96. Bar-tailed Pheasant	*Phasianus reevesi.*
97. Australian Mycteria	*Mycteria australis*
98 Saddle-billed Stork	*Mycteria senegalensis*
99 Rhinoceros Hornbill	*Buceros rhinoceros.*
100 Concave-casqued Hornbill	*Buceros bicornis.*
101. Iceland Falcon	*Falco islandicus.*
102 Saker Falcon	*Falco sacer.*
103. Lanner Falcon	*Falco lanarius.*
104 Greenland Falcon	*Falco grœnlandicus*
105. Spotted Eagle	*Aquila nævia.*
106. Green Boa	*Xiphosoma caninum.*

3913. Skeleton of a Man, mounted (after Beauchène). *Tramond, Paris.*

3914. Skeleton of a Man, for practising dislocations. *Tramond, Paris.*

3915. Human Head, with worn jaw (after Beauchène). *Tramond, Paris*

3916. Child's Head, showing first and second dentitions. *Tramond, Paris.*

3917. Head of Python (after Beauchène). *Tramond, Paris.*

3918. Head of Tortoise (after Beauchène).
Tramond, Paris.

3919. Skeleton of Young Chimpanzee. *Tramond, Paris.*

3920. Skeleton of Gibbon. *Tramond, Paris.*

3921. Skeleton of Crane. *Tramond, Paris.*

3922. Skeleton of Adult Beaver. *Tramond, Paris.*

3923. Model, showing **Muscles** and **Nerves.**
Tramond, Paris.

3924. Entire Head, showing **Nerves, Vessels, Sinus, &c.** *Tramond, Paris.*

3925. Anatomy of the Eye, in 13 pieces. *Tramond, Paris.*

3926. Two Fœtuses. *Tramond, Paris.*

3927. Complete Circulation in the Fœtus.
Tramond, Paris.

3928. Skeleton of Rattlesnake. *Tramond, Paris.*

3929. Lymphatic Vessels, natural size (vulva).
Tramond, Paris.

3930. Lymphatic Vessels, natural size (tongue).
Tramond, Paris.

3931. Lymphatic Vessels, natural size (leg and foot of a child). *Tramond, Paris.*

3932. Lymphatic Vessels, natural size (portion of the large intestine). *Tramond, Paris.*

3933. Lymphatic Vessels, natural size (half the head of a fœtus). *Tramond, Paris.*

3933a. Collection of Preparations of the Nervous System of Molluscs.
Ph. Owsiannikov, University of St. Petersburg.

1–3. A whole nerve-ganglion and two sections, from a thetis.
4. Aeolis.
5, 6. Gastropteron.
7. A Bulla, with eyes.
8. Umbrella.
9. Pleurobranchus
10. Pleurobranchus, section of a nerve-ganglion.
11. Aplysia.
12. Lobulus electricus (Rajae). The section is made of a brain preserved for three years in spirit, the cells and fibres are still seen very well.
13. Dentalium.

microscopical organisms at a constant degree of temperature and moisture. (Exhibitor's construction.)

Prof. Dr. F. Cohn, of the Institute of Vegetable Physiology in the University of Breslau.

This apparatus satisfactorily replaces the germinating apparatus of Nobbe. The seeds are soaked for 24 hours in water, then 200 are placed in each earthenware dish and covered over. The enclosed tin dishes are then filled with water, which keeps in the porous clay dishes the moisture requisite for the development of the seeds. The space between the double walls of the chamber is now filled three-quarters full with water (the height of the water can be seen by the glass gauge), and a small gas flame, governed by a Bunsen's regulator and placed underneath the germinating chamber, keeps the temperature very constant. This apparatus is used for the examination of the germinating power of agricultural seeds, which takes place at the seed control station (Samen-Controll Station) connected with the Institute of Vegetable Physiology. Similar apparatus of different sizes are used in this station continually for the culture of plants, especially microscopical growths, at a constant temperature. They were employed especially by Prof. Cohn in his researches on Bacteria.

3935a. Cultivation Apparatus, with admission of air.

The Imperial and Royal Pathological and Anatomical Institute of the University of Prague (Director, Professor Edwin Klebs).

The circular vessel is filled to half of its height with a mixture of water, glycerine, and sulphuric acid (or sulphate of copper), and the glass globe dipped into the cohesive fluid. The little round vessel contains the substance for cultivation, mostly isinglass gelatine. The open neck of the globe is wrapped round with wadding, and on this is placed the small, broad-brimmed, thick-shelled globe. The air in the globe, as well as the substrata of cultivation, are purified by the infusion of a powerful jet of steam. The introduction of germs, as well as the removal of samples, is effected under a "spray" of permanganate of potash.

Among 70 preparations by this method, only a very few showed a spontaneous development of fungi, whereas "Hyphomycetes" and "Schistomycetes" thrive excellently in them.

3935b. Apparatus for the cultivation of fungi.

The Imperial and Royal Pathological and Anatomical Institute of the University of Prague (Director, Professor Edwin Klebs).

Two glass chambers for microscopical observation :—

a. Filled nearly full with isinglass gelatine. Implantation of "Microsporon septicum" of the year 1872. Ring-shaped progressive development of the "Schistomycetes" round a capillary tube, which contained the vaccine matter (or infection) until the year 1874.

b. Filled half to its height with isinglass gelatine. The vegetation of the "Microsporon sept." ceased early, and the gelatine has to some extent become liquid.

"Hyphomycetes" did not make any appearance, although they thrive in such chambers. Without importation of germs, these chambers, with their contents, will remain free from any formation of fungi.

3936. Apparatus for demonstrating Knight's Experiment on the influence of gravity on the direction of the growth of roots and stems of budding plants. (Exhibitor's construction.)

Prof. Dr. F. Cohn, of the Institute of Vegetable Physiology in the University of Breslau.

Some seeds (by preference Pisum sativum and Zea mays) are soaked for 24 hours in water, and then attached by long needles, which must not pass through the radicle or the plumula, but only through the cotyledons or the endosperm, radially to the circumference of a disc of cork. The apparatus is set in action by connecting the caoutchouc tube of [illegible] cover with the water supply or a water reservoir By regulating the stre[illegible]th of the stream of water the rate of the waterwheel can be increased or di[illegible]ished. The splashing of the water furnishes sufficient moisture for the [illegible]nation of the seeds, so that all the roots are developed centrifugally, [illegible] the stems grow in a centripetal direction. An apparatus similar to [illegible]s employed by Prof. Ciesebcki in the Institute of Vegetable Physiology fo[illegible] researches on the bending downwards of the root (see Cohn's Beiträge zur Biologie der Pflanzen, Vol. I., part 2). The observations can be made through the glass window, which is, however, generally closed by a shutter in order to keep out the light.

3937. Apparatus for Observing the Velocity of Growth in Plants (constructed by Prof. Reincke).

Institute of Vegetable Physiology of Göttingen, Director Prof. Grisebach.

3938. Apparatus for Registering the Growth of Plants.

E. Stöhrer, Leipzig.

The principle of the apparatus is, that the making and breaking of a galvanic current sets in motion a vibration which works between the poles of an electro-magnet, and carries a writing point at its extremity. This pen is pressed against and marks on a drum of paper (which is turned round once in 24 hours by clockwork) a circular line. The portion of the plant under observation is brought into connexion with the pen by means of a delicate system of levers A growth of even $\frac{1}{2}-1$ millimetre of the plant will cause the making and breaking of the current to be attracted and released, the vibrator will thus move, and on the circular line will be recorded curved tracings which indicate the growth of the plant.

The second registering apparatus of which only a photograph is sent is intended for researches on transpiration and the pressure exerted by the root. A sheet of paper divided into minutes and hours is applied to a large brass cylinder, which is turned round on its axis daily or hourly by clockwork. The oscillations of the column of water are written on the paper by means of a cork float bearing a glass pen filled with anilin solution

3939. Apparatus for Researches on the Physiological exchange of Material in the Sheep.

Prof. Henneberg, Agricultural Research Office, Station of the Hanoverian Agricultural Society, Göttingen.

It is necessary for researches on the total exchange of material in an animal to collect completely and separately the fæces and the urine. The stall exhibited serves to illustrate the method in which the experiment was carried out at the Research Station at Gottingen-Weende, when a sheep formed the subject of investigation. The single pen stall was erected in the

chamber of Pettenkofer's respiration apparatus on those days when, in addition, the products of respiration were determined.

See Neue Beiträge zur Begründung einer rationellen Fütterung der Wiederkäuer, edited by Henneberg, Göttingen, 1870–71.

3940. Mercurial Air Pump, for the analysis of blood-gases.
Geissler & Son, Berlin.

The taps of the air pumps and other apparatus must be turned gently after they have been smeared slightly with lard until they appear transparent and clear.

3941. A Sample Collection of Sections of Wood.
Dr. H. Nördlinger, Hohenheim, Württemberg.

The volume, which is the seventh published, although it (as well as the preceding volumes) follows as far as possible the Linnæan nomenclature, contains, however, about 50 newly introduced kinds of wood from various climates. It gives also an extraordinary variety of the inner structures of trees. There are specimens amongst them of the Suæda and Atterstonia of Rapp, which, though so abundant in the Mediterranean, can on account of their abnormal structure be only classified with difficulty.

Especially interesting is the comparison from the originals of different kinds of wood belonging to the same species given in the seventh volume.

3942. Zuca's Drawing Apparatus, modified by Spengel.
A. Wichmann, Hamburg.

3943. Orthoscope. *A. Wichmann, Hamburg.*

3944. Two Large Sachs' Vegetation Flasks, for coloured light, 500 mm. high, and 250 mm. across.
Warmbrunn, Quilitz, & Co., Berlin.

3945. Two Similar Flasks, but smaller, entirely of glass.
Warmbrunn, Quilitz, & Co., Berlin.

3946. Kronecker's Warm Chamber for Digestion.
Warmbrunn, Quilitz, & Co., Berlin.

3947. Ludwig's Strom ühr or Hæmodromometer.
T. Hawksley.

3949. Set of Physiological Operating Instruments.
T. Hawksley.

3949a. Table, with—

(*a.*) Fifteen pieces of the original burners which Middeldorpf, the discoverer of galvano-caustic, employed.

(*b.*) Collection of nine different uterus cauterizers. Wen constrictor. Bow cutter, with five adaptable tubes. Appliance for cauterizing the almond glands. Sliding corrector.

(*c.*) Universal handle for four porcelain cauterizers. Intestine cauterizer. Tooth cauterizer.

(*d.*) Tonsil cutter, for cauterizing the almond glands.
Kgl. chirurgische Klinik der Univ. Breslau (Prof. Dr. Fischer).

3949b. Case, with two cautery handles, and six small cauteries for dentists.
Kgl. chirurgische Klinik (Prof. Dr. Fischer), Breslau.

3949c. Case, with larynx instruments.
Kgl. chirurgische Klinik (Prof. Dr. Fischer), Breslau.

3949d. Complete Case.
Kgl. chirurgische Klinik (Prof. Dr. Fischer), Breslau.

3949e. Case, containing [illegible] most necessary cauteries for practical surgeons.
Kgl. chirurgische K[illegible] (Prof. Dr. Fischer), Breslau.

3950. Hatching Appara[illegible] at a uniform temperature; length 57 c., width 23, height 7[illegible]tims.

The apparatus was made in 1850, b[illegible] not described. In the interior of the hatching apparatus is placed a me[illegible]ic thermometer, the vertical axis of which passes through the bott[illegible]fes, underneath the hatching apparatus, a horizontal branch. [illegible] the latter these is a chimney which, at a given temperature, is brough[illegible] flame and diverts the hot air from the chimney which is placed in the wa[illegible] of the apparatus.
Professor Théodore Schwann, Liége.

3950a. Apparatus for Aërating the water in Aquaria.
Professor U. J. Van Ankum, Director of the Zoological Laboratory of the University of Groningen.

3950b. Elevations and Plan of the Laboratory for Biological Research, presented to the Royal Gardens, Kew, by T. J. Phillips Jodrell, Esq.
First Commissioner of H.M.'s Office of Works.

3950c. Model of a Cupboard 3′ 11″ high; 2′ broad, 1 deep, enclosing 2 cylinders.

1. A whole one with 4 circular shelves.
2. A half one to show the internal structure of the whole.

Laur Esmark, Christia[illegible].

The shelves are made to save room in the museums in arranging specimens preserved in spirits of wine. The cylinders are to be turned round, so that the glass jars, which are placed along the periphery of the circular shelves, can be easily seen or taken out, instead of their being arranged as is generally the case in museums in a straight line, taking double or treble space. In some glass jars is to be seen the manner in which the specimens are fixed to glass threads, which prevent their coming in contact.

3950d. Page's Gas Regulators (2). *E. Cetti.*

3950e. Geissler's Gas Regulator. *E. Cetti.*

SECTION XIX.—EDUCATIONAL APPLIANCES.

South Gallery, Room A.

4000. Apparatus for **Instruction** in **Physical Science.**
Aug. Bel and Co.

1. Thomas's apparatus for showing pressure produced by dilation of liquids. 2. Daniel's hygrometer, for measuring the hygrometic state of the air. 3. Gravesande's hygrometer, for showing the expansion of metal by heat. 4. Bar of iron and copper for showing unequal expansion. 5. Apparatus to show the formation of vapour in a vacuum. 6. Air pump for producing a vacuum. 6*a*. Receiver for ditto. 7. Air pump. 7*a*. Receiver for ditto. 8. Air pump with glass barrel. 8*a*. Receiver for ditto. 9. Long glass tube mounted to show that heavy and light articles fall with equal rapidity in a vacuum. 10. Wire cage. 11. Heron's fountain for showing the elastic force of compressed air. 12. Water hammer (singing). 13. Haldat's apparatus for showing that the pressure of liquids depends upon their height and the surface of the bottom of the columns, and not upon the capacities of the vases. 14. Bunsen's spectroscope, for spectral analyses. 14*a*. Burners for ditto. 14*b*. Platina wire holder for ditto. 15. Hoffmann's spectroscope (2). 16, 17. Polariscopes (5). 18. Magnesium lamp. 18*a*. Phosphorescent tube. 19. Newton's coloured disc for producing white light by rapid rotation. 20–23. Bichromate of potash batteries. 23*a*, 23*b*. Ditto, large. 24. Grenet's battery. 25. Induction coil. 26, 27. Apparatus for decomposition of water. 28. Galvanometer. 29. Apparatus for rotation of liquids by the electric current. 30. Ditto with hollow magnets. 31. Apparatus to show the attraction current. 32. Roget's spiral, for showing ditto. 33. Apparatus to show that the electric spark will not pass in a complete vacuum. 34. Astatic needle. 35. Secondary current apparatus. 36. Telegraph (two parts). 37. Smee's battery, six cells. 37*a*. Grove's ditto, five cells. 37*b*. Bunsen's battery. 37*c*. Set for electrotyping. 38. Set of mechanical powers. 39. Endless screw. 40. Centrifugal machine, four parts. 40*a*. Double cone. 40*b*. Electroscope. 41. One sportsman. 42. Sparkling jar. 43. Electroscope. 44. Whirl. 45. Egg. 46. Set of seven bells. 47. Apparatus for making a hole in a sheet of glass by the electrical discharge. 48. Diamond jar. 49. Henley's table. 50. Discharging rod. 51. Hand spiral. 52. Two brass plates for pith figures. 53. Electrical swing. 53*a*. Holtz electrical machine. 53*b*. Leyden jar, with movable coating. 53*c*. Electroscope. 53*e*. Jar with pith balls. 53*f*. Discharging table. 53*g*. Ditto rod. 54. Geissler's tube for showing direction of the current. 54*a*. Stand for ditto. 55–66. Vacuum tubes and stands. 67. Box of five tubes. 68. Tube and stand. 69. Ditto. 69*a*. Magneto engine for revolving vacuum tubes, &c. 70. Copper hot water funnel. 71. Still and condenser. 72. Small japanned pneumatic trough. 73. Large ditto. 74. Copper water bath, nickel plated. 75. Galvanised iron press. 76. Enamelled cast-iron air bath. 77. Bunsen's filter pump. 78. Ditto, modified by Dr. Frankland. 79. Copper oxygen retort and stand. 80–81*a*. Berzelius spirit lamp. 82. Revolving test tube stand. 83. Twelve holes and pegs, black. 84. Ditto, with glass pegs. 85. Ditto, in two stages. 86, 87. Test

e prismatical, one straight conical, one reversed conical. 307. Organ glass furnace, according to Mr. Bourbouze, showing three different with reflector. 308. Five different sounding boards in wood, and e. 309. Two flat wires for horizontal vibration. 310. Small sup- movable bridges to fix the wire or sounding boards. 311. Sino- cording Mr. Barberau. 312. Circular membrane in caoutchouc ıgeable tension. 313. Ditto of paper, 30 cent. diameter. 314. o, 30 cent. thick. 315. Two tuning forks in C, mounted upon wooden ted to give four vibrations in the second. 316. Two tuning forks in ed between magnetic poles, and intermitting tuning fork in C. ation meter according Mr. Duamel. 318. Apparatus showing the through liquids. 319. Small apparatus, showing the vibration of hout movable reflector.

. Collection of **Models** and **Apparatus** for teaching s, **Sound, Light, Heat, Electricity,** and **Chemistry.**

Matthew Jackson.

pump.
g hemispheres.
oe for weighing air.
ac's apparatus for vapour s.
ıpparatus for vapour den-

alarum.
oothed wheel apparatus.

rks.
fork tube.
ectors on stands.
nses and half lenses, with on card.
ı's pyrometer.
l's ring and ball.
ıvy's apparatus.
le.
machine.
chine.
achine.
chine.
machine.
ondensing electroscope.
pparatus.
te battery.

Zinc plates for Bunsen's battery.
Tangent galvanometer.
Set (11) of Hofmann's tubes with stands (1, with 2 stands) and 1 span stand.
Winkler's gas apparatus.
Imp. sulph. hydrogen apparatus. 3 articles.
Ammonia apparatus.
Collection of small instruments (18) on cardboard.
Organic analysis apparatus. 30 pieces.
Desiccators. Different patterns.
Distilling apparatus for carbon bisulph. (4 articles.)
Assortment of 12 test glasses.
Distilling apparatus. (4 pieces.)
Set of 71 graduated and other glass instruments.
Carbonic acid apparatus. 7 portions in card boxes.
Arrangement of gas burners.
Bunsen's water bath and stand.
Sulph. hydrogen apparatus.
Cleaning brushes.

. **Calculating Disc,** constructed on the system of Pro- onne. Specimen for demonstration, size 50 centimeters, ıgh division; for instruction in schools.

Landsberg and Wolpers, Hanover.

a. **Universal Lever,** for lecturing purposes.

C. Chzechovicz, Russia.

tus consisting of a set of levers and parallelograms, intended to the principle of elementary statics, viz. : —
mbination of forces applied to a body.
ıation of parallel forces.

Testing of the laws of the lever of first and second class.
Examination of the properties of the balances.
Experimental proof of the proposition that every part of a decomposed force produces a corresponding effect.

4002b. Apparatus for showing the **Propagation of Wave-motions.** *C. Chzechovicz, Russia.*

For lecturing purposes, and intended to show the propagation of wave-motion by a system of bi-filar pendulums suspended on movable levers. By changing the plane of suspe[illegible] is enabled to reproduce waves with plane vibrations as well as with [illegible] ones.

4002c. Model of a Plumme -block, for use in classes.

4002d. Model of a Chain-holder, for use in classes.

4002e. Group, with photographs of models, for use in classes. *M. J. Prugger, Munich.*

4003. Arithmometer, by Ma rtinot, for imparting the knowledge of metrical arithmetic and p actical geometry. *Alphonse Martinot, Belgium.*

It is composed of one thousand small cubes of the size of one centimetre. Thirty-two of these are isolated, nine hundred and thirty-two others are united in several groups, forming forty-two pieces. There are ten pieces of two cubes, ten pieces of five cubes, thirteen pieces of ten cubes, bound together in the shape of reglets, or scale boards, one piece of twenty cubes, one piece of fifty cubes, and, finally, seven pieces of one hundred cubes, bound together like plane tables.

The apparatus is completed by four racks, into which, not only the isolated cubes, but the greater number of the groups of cubes may be bracketed so as to form, when united, the cubic decimeter, *i.e.*, the 1,000. It is easy to understand what intuitive power this apparatus places at the disposal of the professor, for teaching children, and for making them understand, in what may be called a material way, the principles of numeration, construction, and deconstruction of numbers, the four fundamental rules of arithmetic, fractional decimals, the formation of the square and cube of numbers, the extraction of their roots, and the generation of metrical measures, &c., &c (Extract from the Report of Mr. André Van Hasselt, Inspector of the Normal Schools of Belgium.)

APPARATUS FOR INSTRUCTION IN PHYSICAL SCIENCE, CONTRIBUTED BY THE COMMITTEE OF THE PEDAGOGICAL MUSEUM, RUSSIA.

Apparatus for Instruction in Physical Science in Military Schools of the Higher and Lower Grades in Russia.

4004. Bauler's Inclined Plane illustrating the acceleration of motion.

4005. Apparatus illustrating the **Expansion** and **Fusion** of **Bodies** from **Heat,** constructed under the direction of the Physical Section of the Pedagogical Museum.

4006. Slides, with weights, for illustrating the force of **Cohesion,** constructed under the direction of the Physical Section of the Pedagogical Museum.

4007. Parallelogram of Forces. By Lermontoff.

4008. Graham's Inclined Plane. By Lermontoff.

4009. Bauler's Lamp, with Gasometer. By Lermontoff.

4010. Parrot's Barometer.

4011. Caoutchouc Electrical Machine. By Kresten.

4012. Apparatus for preparing Oxygen. By Kresten.

4013. Condensator. By Epinu.

4014. Apparatus for **Freezing Water** by means of the **Galvanic Current.** By Lenz.

4015. Agometer or Rheostat. By Jacobi.

4016. Galvanoplastic Apparatus. By Jacobi.

4017. Lamp, with pulverizer (for melting). By Shpakoffsky.

4018. Dry Galvanic Element. By Kresten.

MATHEMATICAL INSTRUMENTS.

4019. Board, with set of pegs, for exercises in studying numbers from 1 to 1000. Made by Fenoult.

4020. Arithmetical Boxes, for exercises in numbers. Made by Fenoult.

4021. Rachoffsky's Class Abacus, for integers and fractions. Made by Fenoult.

4022. Rachoffsky's Abacus, constructed on the system of the St. Petersburg Workshop of School Apparatus.

4023. Nomansky's Abacus, for integers and fractions.

4024. Russian Trade Abacus. Made by Fenoult.

4025. Collection of Measures, for use in schools.(Long superficial, and solid measures, weights, &c.) Made by Fenoult.

4036. Apparatus for demonstrating the theory of perspective Made by Krivkovitch.

4037. Wall Tables for geometrical teaching. Made by Argamakoff.

4038. Collection of class school apparatus for geometrical drawing. Made by Fenoult and Stroukoff.

4039. Manuals and Exercises on all branches of mathematics and geometrical drawing; treatises on the method of instruction in these subjects, adopted in the military schools of Russia. Published by Fenoult.

Maps, Diagrams, Models, and other Appliances for teaching Geography and Astronomy.

4040. Apparatus illustrating the **Motion** of the **Planets** in general, and demonstrating the periods of the transit of Venus in particular, by Kachoffsky.

4041. Planetarium, by Nossoff.

4042. Geographical Pictures on glass for the magic lantern, by Ermolin.

4043. Atlas of Relief Maps. Published by the Juvenile and Pedagogical Library in Moscow.

4044. Relief Map of Asia. By Shulgin.

4045. Model in Relief of an Alpine country. Prepared by pupils.

4046. Orographical Maps of **the World.** By Simashko.

4047. Maps of the five divisions of **the World.** By Ilyin.

4046. Charts (two), showing the distribution of **Forests** and **Mineral Wealth of Russia.** Prepared by the Statistical Committee.

4049. Phenomena of Nature, in pictures :—

Givotoffsky's Geyser, Toundra, Icebergs, and Attols.
Michailoff's Glaciers and Sand Spouts.
Teich's Russian Obas (train of carts), and Bargemen at work on the Volga.
Karasin's Steppes and Desert, two pictures; Sea of Aral, a Caravan in the Steppes, Barkhanes (sand hills in Turkistan), and The Steppes in Middle Asia, two views.

4050. Specimens of **Ermolin's Geographical Pictures** on glass for the magic lantern.

4070. Illustrated Geographical Atlas, by Limberg.

4071. School Atlas, as projected by Colonel Ponlikoffsky.

4072. Geographical Wall-maps, of Ilyin, Rothstein, Sheveleff, Lebedeff, Zooeff, and Michailoff.

4073. Elementary Course of Geography. Systematically arranged in drawings, plans, and maps, prepared by Lapehenko and Michailoff.

4074. Apparatus for teaching the Blind. Collections of plans, maps, manuals, and models for teaching geography to the blind. Prepared and edited by General Grigorieff, director of the Institution for Blind Children in St. Petersburg.

4075. Manuals on all branches of **Geography,** adopted in the **Military Schools** of Russia; **published** by **Fenoult.**

4076. Wall Charts, according to Kotelnikoff's text book.

4077. Atlas, by Petchorin.

4078. Map of the Heavens (Whitall's planispheres altered), by Ilyin.

4079. Apparatus for explaining the seasons (formation of the ecliptic), by Kachoffsky.

4080. Apparatus for explaining the phases of the moon, by Kachoffsky.

4081. Armillary Sphere, by Jenkin.

4082. Armillary Sphere, by Koualsky.

4083. Hemisphere by Koualsky.

Models and Other Appliances for Teaching Mineralogy and Crystallography.

4084. Class Collection of Minerals, with apparatus for their investigation (Heard's system), prepared by Latkin.

4085. Glass Crystals, with axes, illustrative of crystallography, prepared by Skibinevsky.

4086. Glass Crystals, intermediate forms, illustrative of crystallography, prepared by Skibinevsky.

4087. Crystals of Tin (specimens), prepared by Colonel Von-der-Weld.

4088. Models of Crystals in Wood, illustrative of crystallography, prepared by Stroukoff.

4089. Aquarium, Terrarium, and various apparatus for aiding pupils in forming zoological, botanical, and mineralogical collections. From the St. Petersburg Workshop of School Apparatus.

4089a. Charts illustrating natural history, issued under the direction of the Imperial Economical Society. Published by Fenoult.

4089b. Arend's School Atlas of Natural History. Published by Fenoult.

1. Schubert's Zoological Wall Charts. Published by Fenoult.
2. Michailoff's School Atlas of Zoology. Published by Fenoult.
3. Meinhold's Anatomical Tables. Published by Fenoult.
4. Carns' Tables of Comparative Anatomy. Published by Fenoult.
5. Brandt's Atlas of Comparative Anatomy. Published by Fenoult.
6. Bock's Atlas of Comparative Anatomy. Published by Fenoult.

(Note.) The committee consider it unnecessary to send complete school collections of skeletons and stuffed animals, and prefer sending a few specimens only, in order to show the mode of preparation, the price of articles and their use in teaching.

4089c. Specimens of prepared Skeletons and their parts; the skeleton of the bat, of the cat; cervical and lumbar vertebra in section; horn of the bull with the core; leg of the horse; hoof and skull of the same. Prepared by Strembitsky.

4089d. Collection of Furs. Prepared by Fenoult, and at the St. Petersburg Workshop of School Apparatus.

4089e. Specimens of stuffed Mammalia (cat and bat) Prepared by Fenoult, and at the St. Petersburg Workshop of School Apparatus.

ANATOMICAL MODELS, A COLLECTION PREPARED BY STREMBITSKY IN ACCORDANCE WITH THE INSTRUCTIONS OF THE NATURALISTS OF THE PEDAGOGICAL MUSEUM COMMITTEE.

4089f. Thorax (with the same details as Bock Stagger's).

4089g. Vertical section of the Head, with removable larynx

4089h. Vertical section of the Cerebrum.

4089i. Human face, the mouth open.

4089j. Lungs, heart and larynx open.

4089k. Heart.

4089l. Larynx, from behind.

4089m. Larynx, with soft movable epiglotis and elastic communication of the hyoides with the thyroid cartilage.

4089n. Organ of Hearing.

4089o. Eye.

4089p. Spinal Cord and Cerebellum.

4089q. Lower Jaw (organization and progressive development of teeth).

4089r. Vertical section of the Skin.

4089s. Models of Joints (three).

4089t. Complete Model of a man. (2½′ high.)

4089u. Model of a human **Tooth.**

4089v. Models showing the anatomy and physiology of animals; stomachs of ape, kangaroo, tiger, armadillo, seal, manatee. Prepared by Strembitsky.

4089w. Heiser's Models of mammalia (papier-mâché). Prepared by Schindhelm.

4089x. Birds. Specimens of skeletons and their parts; the skeleton of the turkey, with wing and tail feathers; skeleton of the fowl; sternum, wing, foot, skull of the same. Prepared by Strembitsky.

4089y. Stuffed Birds, two specimens (fowl and linnet). Prepared by Strembitsky.

4089z. Model of digestive organs of a Goose. Prepared by Strembitsky.

4089aa. Skeleton of a Frog, Skull of a Poisonous Snake. Exhibited as specimens of skeletons of amphibia and reptilia. Prepared by Strembitsky.

4089ab. Frog in different stages of development. Exhibited as a specimen of preparation of amphibia in alcohol. Prepared by Strembitsky.

4089ac. Frog. Exhibited as specimen of stuffed amphibia. Prepared by Strembitsky.

d. **Collection** of preparations in wax, illustrating the d... nt of the frog. Prepared by Strembitsky.

... e. **Skeleton of the Perch.** Exhibited as specimen of ... Prepared by Strembitsky.

4089af. Injection of the digestive organs of a Fish. Exhibited as specimen of preparation of fishes in alcohol. Prepared by Strembitsky.

4089ag. Illustrat... of ... development of a fish (four characteristic stages). ... y Strembitsky.

4089ah. Spec... fish. (Sturgeon.) Prepared by Strembitsky.

... ations in wax illustrating the ... lopment ... e. Prepared by Strembitsky.

4089aj. Collect... ... ations in wax illustrating the development of *Acipenser* ... Prepared by Strembitsky.

4089ak. Illustration... development of the fish (four characteristic stages.) Pr... y Strembitsky.

4089al. Dissected Insects, two specimens (a beetle and a locust). Prepared by Strembitsky.

4089am. Class collection of Insects, containing 25 typical forms. Prepared by Strembitsky.

4089an. Class collection of Insects on *coloured plates*, prepared by Vasiloff and the pupils of one of the military gymnasia.

4089ao. Class collections of Insects, the insects stuffed and arranged in characteristic postures on natural branches. Prepared by Strembitsky.

4089ap. Specimens of a class collection of insects in separate glass boxes (idea of St. Hilaire).

4089aq. Larvæ of different butterflies, dried (the colour retained). Prepared by Strembitsky.

4089ar. Model of the head of *Œstrus* with movable parts of the mouth (greatly enlarged). Prepared by Strembitsky.

4089as. Model of the head of *Libellula* with movable parts of the mouth (greatly enlarged). Prepared by Strembitsky.

4089at. Model of the head of a spider with movable parts of the mouth (greatly enlarged). Prepared by Strembitsky.

4089au. Model of the head of a butterfly with movable parts of the mouth (greatly enlarged). Prepared by Strembitsky.

89av. **Model** of the leg of an insect, joints movable (greatly ged). Prepared by Strembitsky.

89aw. **Wax Model** of the larva of *Meloloutha* (greatly ged). Prepared by Strembitsky.

89ax. **Model** of *Bombyx mori*, in three stages of its dement (vulcanized india-rubber). Prepared by Strembitsky.

89ay. **Collection** containing six typical forms of Crus-. Preserved in alcohol by Strembitsky.

89az. **Specimen** of *Astacus fluviatilis*. Prepared in a al manner by Strembitsky.

89ba. **Collection** of Crustacea, 10 typical forms, living in a (in form of a table). Prepared by Strembitsky.

89bb. **Collection** of 5 typical specimens of Vermes in ol. Prepared by Strembitsky.

89bc. **Collection** of three specimens of Mollusca in alcohol. ared by Strembitsky.

89bd. **Collection** of 10 artificial specimens of Mollusca, senting them in motion to show the form of their bodies. ared by Strembitsky.

89be. **Collection** of 17 artificial specimens of Mollusca. ared according to the instruction of Professor Dosianikoff by abitsky.

89bf. **A Sea Urchin,** in alcohol. A specimen of the mode eserving Echinodermata, Acalepha, Polypi, and Polycistina. ared by Strembitsky.

89bg. **Botanical Wall Charts.** Prepared by Givotovsky.

89bh. **Botanical Hand Atlas.** Published by Givotovsky.

89bi. **Wall Botanical Chart,** by Bruloff. Published by ult.

89bj. **Botanical Atlas,** by Schubert. Published by Fenoult.

89bk. **Wall Botanical Charts,** one specimen of a coln. Coloured on oil-cloth. Prepared in the Military Gymm of Orenburg.

89bl. **Dendrological Collection.** Illustrations of the of Russia. Prepared by Stolpiansky.

89bm. **Dendrological Collection.** Illustrations of the of Russia. Prepared by Stroukoff.

10. For illustrating the production of Vocal Sounds.
Wooden funnel, with stretched membrane.

11. Diagrams.
(*a.*) Interference of sound.
(*b.*) Section of organ pipe.
(*c.*) Formation of nodes on a string.
(*d.*) Human ear.
(*e.*) Human larynx.

Matthew William Dunscombe, Bristol.

4091. Teacher's Portable Lecture Set for demonstrating the principles of the science of **Light,** comprising the following apparatus :—

1. For demonstrating the Velocity of Propagation.
Movable diagram showing Roemer's observation.

2. For demonstrating the Undulatory Theory.
Model showing propagation of wave by series of rotating particles. The difference between the vibrations of waves of light and sound is shown by the production of both simultaneously in close proximity.

3. For demonstrating the Law of Inverse Squares and Relative Intensities of Lights.
Two square frames, one four times the area of the other, fitted at the corners to four wires, representing rays of light diverging from a point; Wheatstone's photometer, a new and highly improved form; discs of paper in frame with oiled spot for Bunsen's method.

4. For demonstrating the Laws of Reflection :
(*a.*) By plane mirrors.
Plane mirror and candle; pair of mirrors fringed for showing principle of kaleidoscope; movable model (quite new), showing law of angular velocity in ray reflected by rotating mirror.
(*b.*) By curved mirrors :
Convex and concave silvered glass mirrors, carefully worked; semi-cylindrical mirror to show caustic curves; three movable models illustrating the properties of the foregoing.

5. For demonstrating the Laws of Refraction :
(*a.*) At plane surfaces.
Equi-angular glass prism on jointed pillar; disc painted with lines showing paths of incident and refracted rays, for immersion up to the centre in water; movable models to show the law of lines and passage of a ray through a sheet of glass with parallel faces; right-angled glass prism on pillar, to show total internal reflection.
(*b.*) Three-inch diameter double convex lens on pillar and

ground-glass screen; set of six semi-lenses; movable models to show refraction by convex and concave lenses.

6. For demonstrating the Laws of Chromatics:
Set of coloured discs to fit whirling table; achromatic pair of prisms on jointed pillar.

Matthew William Dunscombe, Bristol.

4092. Geography Teaching Apparatus:—

1. Physical and hypsometrical wall map of Belgium, 1·75 metre by 1·60.
2. Hypsometrical wall map of Europe in three colours, 2 metre by 1·75 metre.
3. Physical, political, and commercial wall map of the World, in three colours, 2 metre by 1·75 metre.
4. Oil cloth board map of Belgium and Europe for chalk exercises, 1·30 metre by 1·75 metre.
5. Hypsometrical submergible relief, for facilitating the study of maps, painted plaster, 0·35 metre by 0·30.
6. Typical landscape in relief, painted plaster, for studying geographical nomenclature, 0·70 metre by 0·60 metre.
7. Several classical atlases (chromolithographic).
8. Series of hartographical exercises, for the use of students.
9. Manuals for masters and pupils.

Alexis M. Gochet, Professor at the Normal School of Carlsbourg (Belgian Luxemburg).

4092a. From Mottershead & Co., Manchester.

Figure plates.
Thick horse shoe magnets.
Pair of magnets.
Tate's air pump and receiver.
Small air pump and receiver.
Concave and convex mirrors.
Bottle prism
Sets of phosphorescent powders.
Copper drying oven, with regulator.
Copper still and condenser.
Liebig's condenser.
French blast spirit lamp.
Books of chemical labels
Electro-magnet
Galvanometer.
Bladder frame and weights.
Prism mounted on stand.
Specimen of crystallized bismuth, with glass shade.
Combined Holtz and Bertsth electrical machine.
Pair bismuth and antimony.
Bar to show different expansion of metals.
Voltameter.
Onsted's experiment.
Tewsbury's reflecting polariscope without Nicol's prism.
Bobbin to show induction.
Madgeburg hemisphere.
Electroscope, with condenser.
Vulcanite electrophorus.
Rammerberg's air bath.
Set of apparatus and chemicals according to Roscoe's primer.

4092b. Apparatus from J. J. Griffin & Sons.

Oil lamp furnace, complete.
Blowing machine for do., with tubing iron plate and bag.
Fireclay blast gas furnace with
Gas burner, 16 jets.
Iron tripod stand.
P. P. cylinder and crucible.
Fireclay ventilator.
" cone.
" plates.

P. P. crucible and cover.
Blowing machine for do., with weights.
Blast gas burner, 26 jets, with stand and crook.
Gas crucible furnace complete, large size.
Gas crucible furnace, complete, small size, and P. P. pots.
Gas muffle furnace, complete, large size.
Gas muffle furnace, complete, small size.
Large muffle and bottle necked.
Small „ „
Large clay atmopyre.
Small „
Bone ash cupels.
Plattner's gold assay apparatus.
Pair cupel tongs, with shields.
„ tongs straight, No. 126.
„ „ bent, No. 127.
„ „ charcoal tongs bent, No. 120.
„ „ bent, No. 125.
„ „ bow, No. 128a.
„ „ basket, No. 128.
„ „ bow, No. 124.
„ crucible tongs, No. 4,652.
„ flask tongs, No. 4,576.
Set (4), roasting dishes.
„ (3), cornet pots.
„ (5), scorifiers.
Wrought iron crucible.
„ „
Iron cupel mould.
Boxwood cupel mould.
Ingot mould, conical form on foot.
„ „ „
„ with two holes.
„ „ three divisions.
„ for 12 rods.
Glass parting flask.
Mallet.
Pair boxwood crucible moulds, with three stamps.
Cupeling furnace, with chimney.
Muffle for do.
B. P. tube for do.
Blowpipe set (pocket).
„ in one tin case.
„ in two tin cases in mahogany box.
„ in three tin cases in mahogany box.
Major Ross's blowpipe set (with extras).

Wire stands.
Aluminum plate.
Glass beakers.
G. S. blowpipe with platinum nozzle and stand.
Brass blowpipe lamp.
„ stand.
„ blowpipe.
Stand.
Brass gas blowpipe.
Stand.
Brass Bergmann's blowpipe.
„ German blowpipe.
Stand.
Portable G. S. blowpipe with stand.
Brass „ „
Tin laboratory lamp.
Brass blowpipe on stand.
„ gas blowpipe on stand.
Blowing apparatus.
Tin blowpipe lamp.
Brass stand.
„ pocket blowpipe lamp.
Pair iron tongs, with spoon.
„ brass „
„ „ crucible tongs.
„ „ tongs, long points.
Platina spoon and cover with handle.
Pair brass tongs with ivory points.
„ platina tongs.
Piece platina foil.
Pair G. S. crucible tongs, with plat. tips.
Patina crucible and cover.
Set of three charcoal borers, with charcoal.
Set of Plattner's cupel supports.
„ lead measure.
Agate mortar and pestle. 2 inch.
„ „ $2\frac{1}{2}$ inch.
Plattner's roasting furnace.
„ brass sieve.
Platina spoon and handle.
Platnum wire holder and wire.
Plattner's brass scoop.
„ capsule support.
„ crucible support.
„ „ mould, with box-wood stamps.
„ mould for square blocks.
Albata spoon.
Ivory spoon.
Steel spatula.
Flat file.
Anvil.
Crushing mortar.

4103. Diagram, showing elevation, section, and plan of a working-bench in the Laboratory of the Strasburg University.
Chemical Institution of Strasburg University.

4104. Photographs of a portion of the principal room of the **Laboratory** belonging to the Berggewerkschaft Association of Miners at Bochum.
Berggewerkschaftskasse, Bochum, Rhenish Prussia.

4105. Hofmann's Apparatus for showing the **simultaneous Decomposition** of hydrochloric acid, of water, and of ammonia.
Julius Schober, Berlin.

4106. Hofmann's Apparatus for showing the **Constancy of the Proportions** in the combination of hydrochloric acid gas with water. *Julius Schober, Berlin.*

4107. Hofmann's Apparatus for showing the **Synthesis of Water.** *Julius Schober, Berlin.*

4108. Hofmann's Lecture Room Eudiometer.
Julius Schober, Berlin.

4109. Hofmann's Apparatus for demonstrating that the volumes of oxygen which enter into the composition of carbon and sulphur dioxide are equal to the respective gas volumes of these compound gases. *Julius Schober, Berlin.*

4110. Hofmann's Apparatus for illustrating the **Phenomena of Combustion.** *Julius Schober, Berlin.*

4111. Models from Mitscherlich's **Chemico-technical Collection,** representing—

(1.) A puddling furnace.
(2.) A coke oven.
(3.) The lower part of a blast furnace.

Professor A. Mitscherlich, Münden.

4112. Hofmann's Apparatus (No. 1–16).
Messrs. Warmbrunn, Quilitz, & Co., Berlin.

(1.) Apparatus for the electrolysis of hydrochloric acid, of water, and ammonia.

(2.) Apparatus for illustrating the synthesis of hydrochloric acid.

(3.) Apparatus for showing that hydrogen and chlorine when united suffer no contraction of volume.

(4.) Apparatus for showing that two volumes of water-gas (steam) are formed when two volumes of hydrogen unite with one volume of oxygen.

(5.) Apparatus for showing that ammonia consists of three volumes of hydrogen and one volume of nitrogen.

4115. Photographs of the lecture-room table, showing the provisions made for enabling the audience to see more favourably any experimental demonstration, by employing screens behind the lecture-table. *Professor H. Landolt, Aix-la-Chapelle.*

APPARATUS FOR TEACHING MINERALOGY.

4116. "Student's Elementary Collection of Minerals." *J. R. Gregory.*

4117. Elementary Collections (four) **of Minerals, Fossils, and Rocks,** systematically arranged, in polished wood cabinets; fitted for the use of the student and science-class teacher, and illustrating the various mineralogical and geological handbooks. *Thomas J. Downing.*

4118. Minerals (24) **for Blowpipe Analysis.** In case, for the pocket. Set I. *Thomas J. Downing.*

4119. Minerals (24) **for Blowpipe Analysis.** In case, for the pocket. Set II. *Thomas J. Downing.*

4127. Apparatus for demonstrating the physical properties of **Steam** and the **Steam-jet.** *Dr. L. Bleekrode, The Hague, Holland.*

This apparatus is designed for the lecture-table, and consists in a copper boiler, which is heated by a common gas-burner with six or seven flames. The quantity of water it contains is sufficient to perform all the experiments during an hour, so that it needs no feeding, and the strength of the material permits the production of steam at a pressure of four to five atmospheres.

The following experiments may successively be taken or illustrated one after another:—

I. The principle of the water-gauge in a boiler.
II. The action of the safety-valve.
III. The relation between the tension of vapour and its temperature.
IV. The boiling of water at a pressure higher than the atmosphere.
V. The latent heat of steam and the warming system with steam.
VI. The form of the steam-jet and its property of extinguishing fire. (Here either the vertical or the horizontal valve may be used to lead the steam on to some burning material.)
VII. The producing of a vacuum by the steam-jet. (A metallic box may easily be filled with the escaping steam, and as the box is afterwards shut, it is depressed by the atmosphere.)
VIII. The Giffard's injector. (A glass model is fixed to the horizontal valve.)
IX. The steam producing sound, illustrating the steam-signal and fog-signals.
X. The steam sand blast. (This interesting experiment is performed in a very simple and yet satisfactory manner, by allowing the sand falling through a vertical funnel to mix with the horizontal escaping steam-jet, at the mouth of the valve.)
XI. The electrical properties of the steam-jet. (Armstrong's hydro-electric machine.)
XII. Heat producing work. (Principle of thermo-dynamics.) (Here a model steam-engine is connected with the horizontal steam valve.)

f advantages of this apparatus (already used in several institution
 and Germany) are—
ure, with very little expenditure of time and heat, the illustration
 damental principles of heat on the lecture table.
roduces steam of high pressure, the properties of which may be
 with very little danger.
he relatively small expense (10*l.*) renders possible the introduction o
paratus into schools where physics and mechanics form an importan
part of the system of education.

MIS NEOUS.

4192a. Cosmogr ratus for teaching purposes.
Letellier, Franc

4193. Stativ (stand), with a fixed and a movable pulley, besid string and counter-weight.

4194. Polyspast, to be a ended to the same stand, wi four pulleys, string, and counter eight.

4195. Lever Apparatus, with attached needle (for th balance) and stand.

4196. Twenty-one **Weights** belonging to the foregoing objec
Royal Prussian Chief Mining Department, Bresl

4197. Oscillating Machine (centrifugal apparatus), with t following auxiliary apparatus:—

a. A two-fold brass ring with iron axle.
b. A glass globe with axle.
c. A glass cylinder with inserted Sieboglinder (centrifuge).
d. A double pendulum regulator with throttle-valve.
e. Two balls, joined to each other by a chain.
f. A balancing ruler with sliding weights.

Royal Prussian Chief Mining Department, Bresl

4198. Model of a Suction Pump.
Royal Prussian Chief Mining Department, Bresl

4199. Model of a Fire Engine (force pump).
Royal Prussian Chief Mining Department, Bresl

4200. Four Optical Lenses, with stands, and a rou **Paper-Screen,** with stand.
Royal Prussian Chief Mining Department, Bres

4201. Optical Prism.
Royal Prussian Chief Mining Department, Bres

4202. Steel Magnet.
Royal Prussian Chief Mining Department, Bres

4203. Two Magnetic Needles, with stands.
Royal Prussian Chief Mining Department, Bres

4204. Galvanic Cell, for potassium bichromate.
Royal Prussian Chief Mining Department, Breslau.

4205. Electro-Magnet, with anchor and stand.
Royal Prussian Chief Mining Department, Breslau.

4206. Electrophor, with cover and glass rod.
Royal Prussian Chief Mining Department, Breslau.

4207. Small Induction Apparatus.
Royal Prussian Chief Mining Department, Breslau.

4208. Small Electro-Magnetical Keyboard and Chiming-work, with paper-roll and marking pencil; a primitive telegraph model.
Royal Prussian Chief Mining Department, Breslau.

4209. Air-Pump, with oblique barrel.
Royal Prussian Chief Mining Department, Breslau.

4210. Pair of Magdeburg Hemispheres.
Royal Prussian Chief Mining Department, Breslau.

4211. Fall Tube.
Royal Prussian Chief Mining Department, Breslau.

4212. Two Glass Globes for Air-Pump.
Royal Prussian Chief Mining Department, Breslau.

4213. Mercury Granulation Apparatus, with glass cylinder. *Royal Prussian Chief Mining Department, Breslau.*

4214. Heron's Ball, with glass bowl.
Royal Prussian Chief Mining Department, Breslau.

4215. Freezing Apparatus, brass stand with glass tubes.
Royal Prussian Chief Mining Department, Breslau.

4216. Syphon Apparatus.
Royal Prussian Chief Mining Department, Breslau.

4217. Expansion Apparatus.
Royal Prussian Chief Mining Department, Breslau.

4218. School Microscope, from the Optical Institute of F. W. Schick, Berlin, with two eye-pieces and three object-glasses.
Royal Prussian Chief Mining Department, Breslau.

4219. Collection of Forty Microscopical Preparations from the Institute of Rodig, Hamburg, with explanations by Prof. Dr. Ferd. Cohn.
Royal Prussian Chief Mining Department, Breslau.

The collection serves, in connexion with other means of illustration, for the purpose of teaching in the elementary public schools of the Prussian mining districts (particularly Silesia, Posen, and Prussia proper) the rudiments of the physical and mechanical sciences, and thus to prepare the children of miners for their probable future employment as miners, engine attendants, &c. It is worthy of remark that the money required for the

acquisition of these collections, as indeed for the founding of the appropriate schools, comes from a special fund, which owes its origin and continued maintenance to some clauses in the older German mining laws, according to which the revenues of certain mines are applied to school and church purposes. Through the rapid growth and development of the Silesian mining industry, this fund has risen to the value of 25,000*l.* per annum.

The above-mentioned schools are not to be mistaken for the mining schools proper, or the schools serving as preparatory institutions to these latter, both of which are intended for grown-up pupils.

4219a. Apparatus employed in **teaching,** for exhibiting the action of **Electric Currents** on **Currents** of **Magnetism,**

W. Gloukhoff, Warden of Russian Standard Measures.

In this apparatus the mode of suspension of the movable conductors is entirely new, and consists of a brass tube *A, B, C, D,* through which passes an insulated brass wire *E, F*; the wire and the tube have on their tops the metallic cups *E* and *D*, filled with mercury. Into the cup *E* the steel point of suspension and one end of the movable conductor are plunged, and into the cup *D* the other end.

4220. Universal Rotation Apparatus with Twenty-six Auxiliary Apparatus, viz.:—

1. Centrifugal pendulum.
2. Spheres of different weight.
3. Globe, 100 grammes in weight, movable horizontally, with spring balance, on which the centrifugal force can be directly measured.
4. Two oblique glass-tubes for different kinds of liquids.
5. Glass-balloon.
6. Apparatus for demonstrating the flat spherical form of the earth.
7. Apparatus for flattening of an oil-globule (Ring of Saturn).
8. Ring, chain, ball, cylinder, suspended on a cord.
9. Ball, suspended on a long string, for Foucault's pendulum experiment.
10. Glass-balloon for demonstrating the rising of fluids.
11. Model of a centrifugal blast.
12. Model of a draining and drying apparatus.
13. Apparatus by Coulomb, for causing water to boil by friction.
14. Syren-disc, playing one accord.
15. Savart's toothed wheels.
16. Disc with mirror surfaces and flame-manometer for acoustic flame-images.
17. Stroboscopic cylinder for demonstrating various oscillations according to Quincke.
18. Colour-discs.
19. Oscillating prism.
20. Glass-balloon for producing Newton's colour-rings in thin metal plates of fluid.
21. Stroboscopical discs on the systems of Dove, Poggendorff, &c., illuminated by Geissler's tubes.

22. Becquerel's phosphoroscope.
23. Three rotatory tubes by Geissler.
24. Apparatus for Arago's rotation magnetism.
25. Apparatus for producing inducted currents in a rotating copper disc, with electro-magnet.
26. Large wire-spirals for the phenomenon of the earth's induction. *Emil Stöhrer, Leipsic.*

FIRST SERIES.—APPARATUS FOR SUPERIOR EDUCATIONAL INSTITUTES.

Kinematics, Statics, and Dynamics.

4221. **Model of a Bramah's Hydraulic Press.**

4222. **Model of a Turbine.**

4223. **Model of a Centrifugal Pump.**

4224. **Apparatus** for demonstrating the **Archimedean Principle,** consisting of hollow brass floater, glass cylinder with discharge tube, and graduated glass cylinder.

4225. **Five different Models of Valves.**

4226. **Inclined Plane.**

4227. **Gyroscope,** according to Fessel.

4228. **Gridiron Pendulum.**

4229. **Bevelled Gearing.**

4230. **Windlass,** with tooth and movement.

4231. **Endless Screw.**

4232. **Centrifugal Machine.**

4233. **Apparatus** for demonstrating **Foucault's Pendulum Experiments.**

4234. **Ball-Regulator.**

4235. **Apparatus for Oblique Tubes.**

4236. **Glass Vessel for Liquids** of different specific weights.

4237. **Syren Disc** of brass, sounding **major and minor** chords.

4238. **Apparatus** for demonstrating the **oblate form of the Earth.**

4239. **Colour Disc.**

4240. **Apparatus,** consisting of two balls of unequal weight moving along a wire.

4260. Chromic Acid Element, small, bottle-shaped, with two graphite and one zinc plate.

4261. The same, larger, with two graphite and one zinc plate.

4262. The same, with three zinc and one graphite plate.

4263. Coal-light Apparatus, with small reflector (hand regulator).

4264. Water Deposition Apparatus.

4265. Oxy-hydrogen Gas Apparatus, Werner's construction.

4266. Constant Battery, according to Stöhrer.

4267. Twenty pair of Plates.

4268. Boussole's Tangent, with movable compass.

4269. Horizontal Galvanometer, box-shaped.

4270. Multiplicator, according to Schweigger, for thermo-electrical currents.

4271. Table Galvanometer.

4272. Electro-Magnet, arranged for a table, and for suspension.

4273. Apparatus for showing the rotation of a magnet.

4274. Apparatus for showing the rotation of two magnets, caused by a current.

4275. Magnet, rotating around its own axis.

4276. Electro-Magnetical Oscillating Apparatus, with supporter for Geissler's tubes.

4277. Electro-Magnet, rotating under the influence of terrestrial magnetism.

4278. Electro-Magnet, rotating in a second, with contrivance for lifting weights.

4279. Machine, according to Page.

4280. Electro-Magnet rotating above a steel magnet.

4281. Barlow's Wheel.

4282. Lightning Wheel, according to Neef.

4283. Apparatus, according to Petrina, showing the attraction of parallel currents.

4284. Ampère's Frame, according to Eisenlohr.

4285. Model of Morse's Writing Telegraph.

4286. Induction Apparatus, according to Dubois-Reymond, arranged for medical purposes.

4287. Pocket Induction Apparatus, according to Werners.

4288. Spark Inductor, according to Ruhmkorff.

4289. Spark Inductor, according to Ruhmkorff.

4290. Induction App[illegible] for fundamental experiments.

4291. Steel Magnet, [illegible]e thin plates and keeper.

4292. Dipping Nee[illegible] stand.

4293. Magneto-electri[illegible]**duction Apparatus.**

4294. Blasting Appar[illegible]**r Mining.**

[illegible]. *Leybold's Successors, Cologne.*

Electricity.

4295. Electrical Machine, according to Winter, with different connexions for the condensor.

4296. Holtz's Induction Machine. Diameter of the rotating wheel 520 mm.

4297. Chime with five bells.

4298. Fly-wheel on a circular track.

4299. Lanne's Measure Bottle.

4300. Discharging Rod.

4301. Double Fly-wheel.

4302. Battery of four Leyden Jars.

4303. Pair of fine Gold-leaf Electrometers.

4304. Pair of fine Gold-leaf Electrometers, with **Zamboni's Column,** improved according to Fechner.

E. Leybold's Successors, Cologne.

SECOND SERIES.—APPARATUS AND INSTRUMENTS FOR ELEMENTARY SCHOOLS.

Kinematics, Statics, and Dynamics.

4305. Inclined Plane, simple.

4306. Windlass (Göpel).

4307. Rod Windlass.

4308. Wooden Screws, with threads of different section.

4309. Wheel on Axle, with stand.

4310. Reel, with stand.

4311. Six Lever Apparatus, for demonstrating different laws of leverage.

4312. Apparatus for illustrating the action of pulleys.

4313. Glass Model of a Suction and Forcing Pump.

4314. Glass Model of an Hydraulic Press.

4315. Glass Model of a Fire Engine.

4316. Segner's Water-wheel.

4317. Model of a Diving Bell.

4318. Apparatus for illustrating the **Expansion** and **Compression of Air.**

4319. Fly-wheel of glass.

4320. Fly-wheel.

4321. Rotating Suction Siphon.

4322. Apparatus for demonstrating the uniform transmission of pressure in liquids.

4323. Model of a Suction-pump.

E. Leybold's Successors, Cologne.

Molecular Physics.

4324. Hand Air-pump.

4325. Pair of Magdeburg Hemispheres.

4326. Scale Manometer.

4327. Sound Apparatus, for weighing air.

4328. Apparatus for illustrating that a vacuum can be filled by a liquid through atmospheric pressure.

4329. Atwood's Machine.

4330. Barometer.

E. Leybold's Successors, Cologne.

Light.

4331. Prism.

4332. Astronomical Models, illustrating course of the rays of light.

E. Leybold's Successors, Cologne.

Heat.

4333. **Apparatus,** glass, for demonstrating the **Effect of Steam.**

4334. **Apparatus,** glass balloon, and ring.

E. Leybold's Successors, Cologne

Magnetism.

4335. **Simple Diving Element.**

4336. **Double Diving Element.**

4337. **Galvanoplastical Apparatus.**

4338. **Pair of Carbon Points,** with handles.

4339. **Apparatus** for making **Wires red hot.**

4340. **Water Decomposition Apparatus.**

4341. **Electro-magnet,** with two binding screws.

4342. **Electro-magnetical Driving Machine.**

4343. **Induction Apparatus,** for extra current and secondary current.

4344. **Bar Magnets.**

4345. **Horse Shoe Magnet.**

E. Leybold's Successors, Cologne

Electricity.

4346. **Simple Electrical Machine.**

4347. **Electrical Tuft.**

4348. **Simple Gold-leaf Electrometer.**

4349. **Fundamental Apparatus,** according to Werner, friction electricity, magnetism, and galvanism.

4350. **Electrophorus,** 210 mm. in diameter.

4351. **Electrical Shower of Balls.**

4352. **Electrical Pistol.**

4353. **Electrical Discharging Rod.**

4354. **Simple Chime of Bells.**

4355. **Leyden Jar,** 156 mm. high.

4356. **Isolating Stool.**

E. Leybold's Successors, C

THIRD SERIES.—APPARATUS AND APPLIANCES FOR TEACHING CHEMISTRY.

Chemistry.

4357. Series of **Reagent Jars,** with enamelled labels and inscriptions.

4358. Carbonic Acid Apparatus, according to Bunsen.

4359. Potash Apparatus, according to Liebig.

4360. Potash Apparatus, according to Mohr.

4361. Potash Apparatus, according to Mitscherlich.

4362. Sulphuretted Hydrogen Apparatus.

4363. Drying Apparatus, by means of sulphuric acid.

4364. Combustion Stove, according to Bunsen, with 25 burners.

4365. Combustion Stove, according to Glaser, with 20 burners.

4366. Set of 12 Bohemian Glass Beakers.

4367. Set of 6 Bohemian Glass Beakers.

4368. Bellows, with lamp, for glass-blowing.

4369. Burette, according to Bink's, 50 cc. in $\frac{1}{5}$.

4370. Burette, according to Gay Lussac, 50 cc. in $\frac{1}{10}$.

4371. Porcelain Burette Stand, with eight burettes (dropping glasses).

4372. Glass Burette, according to Geissler, 50 cc. in $\frac{1}{5}$.

4373. Burette, with porcelain stand.

4374. Burette, with stand of polished wood.

4375. Combination Cylinder, according to Mohr, 1,000 c.

4376. Dephlegmator, according to Staedler.

4377. Azotometer, according to Knop, modified by Wagner.

4378. Filtering Frame, of iron, with leaden base.

4379. Filtering Frame, of brass, with wooden base.

4380. Universal Stand, according to Werners.

4381. Set of 9 Evaporating Dishes, of enamelled iron.

4382. One Litre **Clarifying Bottle,** with glass and stopper.

4383. Series of 8 **Boiling Jars,** according to Erltenmeyer.

4384. **[illegible]ing Apparatus,** glass.

4385. Set of 7 **Cork Borers,** in brass.

4386. **Bunsen Burner,** with stand.

4387. **Seven Burette-holders,** three rings, chimney, retort.

4388. " " with regulator.

4389. " " with regulator and stop-cock.

4390. " " with three pipes.

4391. " " with seven pipes.

4392. " " with twelve pipes and tripod.

4393. **Gas Stove,** with [illegible] burners and stop-cock.

4394. **Three Glowing Lamps**, according to Masté.

4395. **Blow-pipe Case.**

4396. **Pipette Stand,** of polished wood; porcelain stand.

4397. **Polished Revolving Reagent Bottle Frame,** to hold 36 bottles.

4398. **Unpolished Reagent Bottle Frame,** according to Llandolt's, with 18 bottles.

4399. **Crucible Tongs,** of brass.

4400. **Series of Glass Funnels,** Bunsen's shape.

4401. **Copper Water-bath,** 9-inch.

4402. **Copper Water-bath,** on tripod.

4403. **Constant Level.**

E. Leybold's Successors, Cologne.

4404. **Hestermann's Technological and Physical Science Apparatus:—**

4405. **Flax** and its applications.

4406. **The Cotton Plant** and its use.

4407. **Wool** and its application.

4408. **The Honey Bee** and its industry.

4409. **Leather,** its preparation and employment.

4410. **Silk,** its production and application.

4411. **Paper,** its manufacture and use.

4412. **Glass,** its manufacture and employment.

4413. **Illuminating and Heating Materials,** their production and use.

4414. Dyeing and **Cotton Printing.**

4415. Collection of Products, III. Course.

4416. Iron, its production, manufacture, and use.

4417. Collection of Caterpillars, with text, by Director Dr. Bolan.

4418. Cabinet containing Silkworms.

4419. Forest Herbarium, Parts I. and II.

4420. Herbarium of Poisonous Plants.

4421. Herbarium of Grasses.

Chr. Vetter, formerly Ludw. Hestermann, Hamburg.

Apparatus and Instruments for Chemists and Natural Philosophers.

4423. A Chemical Scale for 1 ko. weight, indicating 1 milligr., with special balance and scales, and stopping arrangement; gilt; the scales are of platinum, in glass case.

4424. Set of Weights belonging to the same, gilt, from 1 ko. downwards.

4425. Two Sets of Weights, from 50·0 grm. downwards, nickel plated.

4426. Sets of Weights of Rock Crystal, from 200·0 gr. downwards.

4427. A Normal 500·0 gr. Weight, of rock crystal.

W. J. Rohrbeck, J. F. Luhme & Co., Berlin (Dr. Herm. Rohrbeck).

Physics.

4428. One-barelled Air Pump, with standing glass tube, double acting, on wooden stands.

4429. Attwood's Machine, with pendulum.

4430. Seconds Pendulum, on stand.

4431. Mack's Galilei's Fall Kennel.

4432. Centrifugal Machine, with auxiliary apparatus.

4433. Hydraulic Press.

4434. Air Pump, with two glass tubes, and Babinet's stopcock.

With apparatus :—*a.* Barometer test; *b.* Magdeburg hemispheres; *c.* Mercurial granulation; *d.* Globe (recipient); *e.* Electric egg; *f.* Cylinder for bursting of bladders; *g.* Freezing apparatus.

4435. Mach's Wave Apparatus, for illustrating the longitudinal and transversal waves.

4436. Mach's Apparatus for **Sound Reflection.**

4437. Mach's Apparatus for **Refraction and Reflexion.**

4438. Mach's Apparatus for demonstrating the **Law of Refraction** by means of fluorescent liquids.

4439. Mach's Apparatus for demonstrating the **Effects of Lenses.**

4440. Model of a Screw, of wood.

4441. Model of a Screw, of wood.

4442. Crown Glass Prism.

4443. Flint Glass Prism.

4444. Poly Prism.

4445. Hollow Prism.

4446. Universal Kaleidophon, for illustrating Lissajou's figures.

4447. Meyerstein's Heliostat.

4448. Astronomical Telescope, on a wooden stand with [illegible]

4449. Pocket Spectroscope, according to Professor Em[illegible] [illegible] one prism, and contrivance for specially placing the [illegible]

4450. Another Specimen of the same kind

4451. Thermo-electrical Battery, according to Clamond.

4452. Thermo-electrical Battery, according to Noe

4453. Lane's Measure-bottle, fine adjustment, with scale and vernier.

4454. Separable Leyden Jar.

4455. Electroscope, after Professor Mach, for demonstrating that electricity lies on the surface of excited bodies.

4456. Holtz's Electrical Machine.

[illegible] apparatus:—*a.* Lightning-tube. *b.* Lightning-plate [illegible] *d.* Dancing dolls. *e.* Contrivance for breaking glass [illegible] Henley's discharging rod. *g.* Discharging rod. [illegible]

4457. Pair of Concave Mirrors, brass, 16 inch diameter, [illegible] in pairs, with contrivance for adjustment [illegible] heat experiments.

4458. Two Sectional Models of Steam-engines.

4459. Model of a Screw Steamer.

4460. Lever Pyrometer.

W. J. Rohrbeck, J. F. Luhme & Co., Berlin (Dr. H. Rohrbeck).

Chemistry.

4461. Plattner's Assay-balance, for blow-pipe purposes, in mahogany case, with 1 gr. weight, indicating $\frac{1}{10}$ milligr., with weights.

4462. Balance, on stand, according to Wackenroder, to carry 20 gr., and indicating 1 mgr., &c.

4463. Technical Balance, on stand, to carry 500 gr., and indicating 5 mgr.

4464. Mohr's Tare-balance, in mahogany scale case, with brass column, bow-scales, and ebonite plates, to carry 1 kilogramme, and indicating 1 centigr.

4465. Scales, for weighing substances affecting metals, to carry 250 gr., and indicating 5 mgr.

4466. Complete Mohr's Balance, for determining the specific weight of liquid and solid bodies.

4467. Mohr's Balance, with one arm.

4468. *a.* **Exsiccator,** according to Schrötter, consisting of tubulated glass jar on a frosted glass plate, framed in wood, with crucible stand, and chloride of calcium tube.

4469. *b.* **Exsiccator,** according to Fresenius, consisting of glass cylinder, &c.

4470. *c.* **Exsiccator,** according to Fresenius, with frosted glass plate.

4471. *d.* **Exsiccator,** according to Luhme, with porcelain vessel for sulphuric acid, and etagère.

4472. *a.* **Drying Closet,** according to Fresenius, of copper, with two tubes and thermometer.

4473. *b.* **Drying Closet,** according to Fresenius, of copper, with grate, wire net, thermometer, and chloride of calcium tube, for drying pulverised substances.

4474. *c.* **Drying Closet,** according to Rammelsberg, with two tubes and thermometer.

4475. *d.* **Drying Closet,** according to Rose, with double sides, two tubes, and thermometer.

4476. **Drying Box,** according to Fresenius, for agricult[...] chemical purposes, with thermometer.

4477. **One Burner** to the same.

4478. **Burner, Blast, and Lamp.**

4479. a. **Eolipile,** of brass plate.

4480. b. **Berzelius' Lamp,** on porcelain plate.

4481. c. **Lamp,** according to Mitscherlich.

4482. d. **Simple Burner,** with glass tube.

4483. e. **Bunsen's Jet Burner,** uni-radiating, with [...] flame.

4484. f. **Bunsen's Burner,** with chimney, and fork-[...] heater.

4485. g. **Bunsen's Burner,** with star-ring, chimney, [...] blow-pipe apparatus.

4486. h. **Finkner's Burner,** with gas and air regulator.

4487. i. **Finkner's Burner,** with star-ring and chimney.

4488. **Griffin's Burner.**

4489. **Burner,** according to the Viennese mod[...]

4490. **Double-radiating Jet Burner.**

4491. **Treble-radiating Jet Burner.**

4492. **Iserlohn Gas-stove Burner,** with one emiss[...]

4493. **Iserlohn Gas-stove Burner,** with double emiss[...]

4494. **Blow-pipe-table Adjustment,** according [...]

4495. **Blow-pipe-table Adjustment,** with two st[...] [...] pipes, according to Rohrbeck.

4496. **Apel's Stove.**

4497. **Universal Stand,** of iron, with Finkner's pat[...] [...] holders.

4498. **Iron Filtering Stand,** with three rings.

4499. **Schellbach's Retort-holder.**

[...] *F. Luhme & Co., Berlin (Dr. He[...]*

4500. Professor A. W. Hofmann's Apparatus and Instruments.

a. Apparatus for ascertaining the volume proportions of hydrogen and chlorine, consisting of V-shaped tube, with two glass stop-cocks, and iron stand.

b. Apparatus for proving, that at the formation of the HCl, one volume Cl and one volume H combine; consisting of a glass tube, with two stop-cocks, decomposition apparatus, and two pipe supporters, calcium chloride cylinder, and a vessel for the electrolytical analysis of hydrochloric acid.

c. Water-decomposition apparatus for demonstrating that 2 vol. hydrogen and 1 vol. oxygen are the volume proportions of water; consisting of a triangular tube, with two stop-cocks, and platinum electrode (the tube also graduated); iron stand.

d. Steam-tight apparatus, consisting of one graduated barometer-tube with envelope-pipe, iron stand with holder, measuring apparatus, boiling and cooling vessel and serpentine-pipe.

e. Apparatus for ascertaining the volume proportions of nitrogen and hydrogen in ammonia; consisting of tube with stop-cock and stopper, a glass cylinder, movable table, and glass bowl.

f. Apparatus for ascertaining the volume proportions of the elementary constituents of HCl, H_2O, and NH_3, by electrolytical means; consisting of two glass apparatus with coal-electrodes, a water-decomposition apparatus with platinum electrodes, and three iron stands.

f[1]. Apparatus for proving that at the combination of the respective elementary gases HCl, H_2O, and NH_3, always two vol. gas are formed; consisting of three V-shaped tubes with platinum electrodes, and three iron stands.

g. Apparatus for demonstrating that the gases H and Cl combine in the constant proportion of 1 : 1 into hydrochloric acid; consisting of a glass tube with stop-cock, and two ground-in stoppers, with stand.

h. Apparatus for the decomposition of nitric acid; consisting of a little platinum piston, a stand, a funnel-tube with stop-cock, a pneumatic trough, and a cylinder.

i. Apparatus for demonstrating the equal volume proportions of simple and compound gases; consisting of steam apparatus, steam-conducting pipe, glass apparatus with five stop-cocks, and an iron stand.

k. Apparatus for making experiments with sulphurous acid.

l. Apparatus for the decomposition of hydrogen phosphide; consisting of V-shaped tube with two electrodes, and a stand.

m. Apparatus for showing the oxidability and capability of reduction of the gas-flame; consisting of a copper crucible, with tripod and gas-burner.

[illegible] Apparatus for the electrolytical decomposition of the [illegible] and [illegible], consisting of V-shaped tube with platinum [illegible].

[illegible] for bottles, with octagonal stopper, [illegible] [illegible] and formula on the stoppers.

[illegible] Apparatus for demonstrating the Valu[illegible] [illegible], according to [illegible].

[illegible] Cylinder of [illegible], on stand.

[illegible] Cylinder of Brass.

[illegible] Cylinder of Glass, according to Hofmann.

[illegible] Two Agate Mortars, with pestle, 65, 150 [illegible].

[illegible] Three Glass Mortars, with pestle, 60, 10[illegible] [illegible].

[illegible] Three Powder Mortars, of porcelain, with

[illegible] Mill Mortar of Iron, 155 mm. diam.

[illegible] Diamond Mortar.

[illegible] Diamond Mortar.

[illegible] Caustic Potash Form, [illegible] 12 [illegible]

[illegible] Filtering Pump, according to Bunsen.

[illegible] Pump, according to [illegible], for drying [illegible]

[illegible] Alkalimetrical Apparatus.

[illegible] Burette Stand, with [illegible] movable burettes.

[illegible] Four graduated Cylinders, 250 0, [illegible]

[illegible] Mixing Bottle [illegible] 1000 [illegible].

[illegible] Measuring Flasks, [illegible]

[illegible] Measuring Flasks, [illegible] with stopper.

[illegible] Carbonic Acid Apparatus, according to [illegible]

[illegible] Carbonic Acid Apparatus, according to R[illegible]

[illegible] Carbonic Acid Apparatus, according to Sch[illegible]

[illegible] Hand Aräometer.

[illegible] Three different polished Retort-holders.

[illegible] Four different Blow-pipes.

[illegible] Two [illegible] Pincers.

4527. One Dozen Funnels.

4528. One Dozen Boiling Jars.

4529. One Dozen Pistons.

4530. Six Sets of Glass Bowls.

4531. One Dozen of Woulff's Jars.

4532. One Dozen Retorts.

4533. Six Glass Stop-Cocks.

4534. Six Separatory Funnels.

4535. Six Potash Apparatus.

4536. One Sulphuretted Hydrogen Apparatus.

4537. One Deplacement Apparatus, according to Robiquet.

W. J. Rohrbeck, J. F. Luhme & Co., Berlin (Dr. Herm. Rohrbeck).

Technology.

4538. Wooden Model of a Blast Furnace.

4539. Wooden Model of a Shaft Furnace.

4540. Wooden Model of a Puddling Furnace.

4541. Wooden Model of a Rolling and Stamping Mill.

4542. Wooden Model of a Silver-Ore Refining Furnace.

4543. Wooden Model of a Double Roasting-Furnace for Copper.

4544. Wooden Model for demonstrating the Manufacture of Sulphuric Acid.

4545. Wooden Model of a Glass Furnace (Siemens' regenerative system).

W. J. Rohrbeck, J. F. Luhme & Co., Berlin (Dr. Herm. Rohrbeck).

4546. Apparatus for the graphical demonstration of the **Law** of **Descent.**

4547. Apparatus for determining the **Linear Expansion by Heat,** by means of reading by mirror reflection.

4546. Müller's Wave Disc.

(*a.*) Stativ (stand).
(*b.*) Portfolio with stroboscopical discs.

4549. Some **Drawings** which Müller used, in the years 1840 and 1850, in his lectures explanatory of apparatus.

Physical Institute of the University of Freiberg, Baden (Prof. Dr. A. Claus).

SECTION XX.

West Gallery, Upper Floor, Room O.

COLLECTION OF APPARATUS AND PHOTOGRAPHS ILLUSTRATING ITALIAN SCIENCE.

4552. Photographs [illegible]senting various **Scientific Instruments** in the Obser[illegible] of the Collegio Romano, Rome.

Padre Secchi, Director, Rome.

No. 1. Spectroscope applied to the [illegible]fractor of Merz, provided with a net work by Rutherford.

No. 2. Spectroscope with netw[illegible] applied to the refractor of Merz, with the cover adapted to the plate of [illegible]twork.

No. 3. Spectroscope with five prisms, with double passage of the ray by reflection, and with automatic movement to bring within the eye-piece the various dispersed rays.

No. 4. Spectroscope with three angular prisms, and one with direct vision [illegible] the collimator.

No. 5. Large object prism of Merz, of 6 inches, for the spectral analysis of the stars.

No. 6. Meteorograph of Padre Secchi.

No. 7. Curves traced with the meteorograph.

4553. Drawings, on a large scale, **of the Meteorograph** of Padre Secchi, with printed description annexed.

Observatory of the Collegio Romano, Rome: Director Padre Secchi.

4554. Photograph of the Vertical or Zenith Telescope for the observation of stars culminating near the zenith.

Prof. Lorenzo Respighi, Director of the Royal Observatory of the Campidoglio, Rome.

The vertical or zenith telescope is intended for the measurement of [illegible] stars culminating near the zenith, with the use only [illegible] mercurial horizon, without need either of inver[illegible] level. The telescope being directed towards the nadir, on the reflect[illegible] [illegible] below the object-glass, it is poss[illegible] [illegible] to determine the nadir or the first vertical with a fixed [illegible] [illegible] with the movable thread, the reflected imag[illegible] [illegible] in the field of the telescope, and the [illegible] with the micrometric screw. In o[illegible] [illegible] it is necessary that the re[illegible] [illegible] over the whole object-glass, which wil[illegible] [illegible] D of the reflecting horizon from the object-glas[illegible] [illegible] $D = \frac{A}{2 \tan Z}$, where A is the apertur[illegible] [illegible] and Z the zenith distance of the star.

In Table VI [illegible] represented the zenith telescope [illegible] the Royal Observatory of the Campidoglio, constructed by Signor Fri[illegible]

Monaco, from a design given by Professor Respighi. The telescope is mounted as in transit instruments, and may also be used as a meridian telescope; the object-glass, made by Signor Merz, of Monaco, has a free aperture of $0 \cdot 108^m$, with a focal distance $1 \cdot 582^m$. The micrometer is composed of 11 fixed equatorial threads and two movable threads, with a fixed meridian thread. The eye-piece can be moved with the greatest ease, whether in the meridian or vertically. The micrometer can be turned 90° to render the threads parallel to the meridian, and then the instrument serves as a transit-instrument.

4555. Photographs representing the Daily Drawings of the Solar Chromosphere, made by the spectroscope of Professor Lorenzo Respighi.

Prof. Lorenzo Respighi, Director of the Royal Observatory of the Campidoglio, Rome.

On the 26th October 1869, at the Observatory of the Campidoglio, the spectroscopic observation and the daily representation of the chromosphere on the solar horizon were for the first time undertaken, and this work has been regularly continued up to the present time. The instrument used in these observations is an equatorial by Merz, with telescope of 4½ inches aperture, to which is applied a spectroscope with direct vision, by Hoffmann, with five prisms, with circle of position to fix the place of the various parts of the chromosphere and of the protuberances. Notwithstanding the small dimensions of the instrument and the moderate dispersion of the spectroscope, the chromosphere and the protuberances are clearly exhibited even in their smallest details.

The Photographs I., II., III., IV., and V. represent 140 drawings of the chromosphere made with this apparatus by Professor L. Respighi.

4556. Photographs of Scientific Instruments in the Institute of Physical Science, Royal University of Rome.

Director, Prof. Blaserna.

1. Balance of precision made by the mechanician Scateni, of Urbino; the suspension very simple and excellent. With a weight of kilogram 2 per scale. Indicates to $\frac{1}{2}$ milligramme.

2. Universal wheel, made in the workshop of Galileo, in Florence. It allows rotary motion to be produced in cylinders and discs in horizontal and vertical directions with the most different velocities.

3. Scott's Phonautograph, made by the machinist De Palma, of Naples. The writing lever has a special arrangement devised by Mr. Campbell, lecturer at the Physical Science Institute, by which it rests only upon the centre of the vibrating membrane, while the other support transforms the vibrations into movements parallel to the axis of the rotating cylinder.

4. Instruments of precision, made by Starke and Kammerer, of Vienna:—(A.) Complete theodolite; horizontal and vertical circle, which permits, by the aid of microscopes with a movable ocular thread, to read up to 1″. (B.) Apparatus for the measurement of the indices of refraction. For the reading are added two microscopes with movable ocular threads, allowing a direct reading of 1″. Repeating movement, with excellent arrangement of the plate bearing the prism. (C.) Cathetometer, with movable ocular thread, allowing a reading of $\frac{1}{100}$ millimetres.

5. Magnetic instruments, according to Lamont, made by Dr. Carl, of Munich, Bavaria:—(A.) Theodolite, for the absolute measurement of declination and of the horizontal component. The two microscopes allow the reading

[illegible]

[illegible]

[illegible] Drawings [illegible]

[illegible]

[illegible] Photograph[illegible]

[illegible] Photograph[illegible]

[illegible]

4560. Photograph of the "Cecchi Electrical Machine," rmed of two discs, which are placed partially one over the other, e one of caoutchouc, and the other of glass, with parallel axes.

Prof. Filippo Cecchi, Florence.

The Cecchi electrical or dielectrical machine is composed of two discs th parallel axes. The upper disc is of india-rubber, and is supported by axis of glass; the one below is of glass on an axis of metal. The axis of e glass disc has on one side a large pulley, and the axis of the other disc a ıall pulley, and by means of a continuous cord, not crossed, there is transtted to the caoutchouc disc a rotatory motion eight or ten times faster than at of the glass-disc; both the discs turn in the same direction. The discs e partially placed one above another, and are very close but without touching. ıe upper part of the caoutchouc disc passes between two arms furnished th metallic points, and connected with a large sphere of brass insulated at e extremity of a long glass rod. To this sphere is attached the hook of a ndenser or else a Leyden jar formed by a barometer-tube with very thick ılls. The lower part of the same disc passes before a comb of metallic ints, called a T-comb, which communicates with the external armature of e condenser, and with two friction cushions of the glass disc, and then with e ground, and also with an exciter formed by a tube of brass with a ball at e end. When the discs are revolving, the large sphere becomes charged ith negative electricity. This machine with discs of 80 centimètres diameter is given sparks of the length of 42 centimètres free in the air.

4561. Photograph of the Universal Instrument of Luigi elli, for levelling operations, trigonometrical and graphic, by ing adapted to the prætorian tablet. *Luigi Pelli, Florence.*

The universal instrument of Luigi Pelli serves for levelling operations, cause it is mounted like the most exact telescope-levels. It serves for the me trigonometrical operations as the theodolite, inasmuch as its azimuth rcle is formed in the same manner as that of the repeating theodolite, having, owever, only two verniers. Moreover, this instrument is provided with alidades, and can be applied to the prætorian tablet like the dioptric, and is ailable for all the operations that can be performed with the same. In such anner are obtainable measured and graphic angles. The alidade is placed as to coincide with the plane of the tablet by means of a central screw tuated in the column which sustains the telescope. A point fastened with rings within the screw marks on the paper the centre of the azimuthal rcle.

4562. Photographs representing various Scientific Inruments in the Cabinet of Geodesy and Hydrometry, Royal niversity of Padua. *Prof. Legnazzi, Director, Padua.*

GROUP I.—TELESCOPES, SQUARES, AND PRISMS.

1. Ramsden's Dynamometer, made in the workshops of the Royal Observatory of Padua (1866).
2. Dioptric with pointers by the Giuseppe Stefani, of Padua (1827).
3. Squares with triangular prism, by Ertel, of Monaco (1872).
4. Square of Wollaston, by Merlo, of Milan (1869).
5. Model of telescope for public instruction, designed by Professor Legnazzi, and constructed by Francesco Pasini (1875).

6. [illegible] telescope by the celebrated Geo. Dollond, of [illegible]
7. Telescope with distance-measurer, by Rochon (1828).
8. [illegible] squares, simple, from the workshop of the Royal [illegible] of Padua.
9. [illegible], by Ertel, of Monaco (1873).
10. Camera Lucida, by the distinguished optician Amici, of Florence ([illegible]
11. Reflection square from the Tecnomasio of Milan (1868).
12. Reflection square and [illegible], by Goldschmid, of Zurich (187[illegible]
13. [illegible], by Ertel, of Monaco (1874).
14. [illegible] with distance-measurer, by Rochon (1869).
15. [illegible] telescope, by the optician Plossl, of Vienna (1845).
16. [illegible] with compass from the Tecnomasio of Milan (18[illegible]
17. [illegible]
18. [illegible] terrestrial telescope, by Prosdocimi, of Padua, 1872.
19. [illegible] from the Tecnomasio of Milan.
20. [illegible] from the Tecnomasio of Milan.
21. [illegible] of the human eye considered as a telescope, made by [illegible] in Padua (187[illegible]).

Group II.—[illegible], Measuring Circles, and Theodo[illegible]

1. [illegible], more than three centuries old; instead of [illegible] it is furnished with the diagonal scale designed by Don Pedro N[illegible] [illegible]. The [illegible] is worthy of observation [illegible]

[illegible] by Shuttleworth, of London [illegible] [illegible] of Paris [illegible] [illegible] gives five seconds with [illegible]

[illegible] Breithaupt, of Monaco [illegible]

[illegible] constructed [illegible] the Imperi[illegible] [illegible] of Vienna; the horizontal circle gi[illegible] [illegible] (1852).

[illegible] Monaco, a remarkable [illegible]

[illegible] of Paris, which gives [illegible] (1822) [illegible] which gives 10" [illegible]

[illegible] of Monaco [illegible] gives [illegible] an excel[illegible] [illegible]

[illegible] of Paris [illegible] an [illegible] instrume[illegible] [illegible]

[illegible] degrees, [illegible] [illegible] W[illegible] [illegible] topographical [illegible]

[illegible] Tablets

[illegible] constructed in th[illegible] [illegible]

[illegible] constructed by [illegible] [illegible] of Padua (1833). This is [illegible] the configuration of the ground.

3. Gnomon, for the rotation of the dioptric.
4. Dioptric, with pointers and telescope, by Giuseppe Stefani.
5. Small spherical level from the Tecnomanasio of Milan (1869).
6. Dioptric, with telescope, by Alemanno, of Turin (1870).
7. Small level, with bubble of invariable length, designed by Professor Legnazzi, and constructed by his pupil Franeesco Pasini (1875).
8. Small common level of the Italian tablet.
9. Prætorian tablet of the Italian system by Rochetti, of Padua, without the mirror and the accessory instruments in order to show its construction.
10. Small metrical chain of precision, of 10 meters, which was employed in the operations of the measurement of the arc of meridian of France (1802–1817).
11. Topographical compass, by Giuseppe Rodella, of the Royal Observatory of Padua (1795).
12. Prætorian tablet of the German system by Carl Starke, of Vienna, without the mirror, in order to show its construction (1856).
13. Prætorian tablet of German system, by Carl Starke, of Vienna, complete (1842).
14. Small level, by Ertel, of Monaco (1874).
15. Dioptric, with telescope and distance-measurer, by Carl Starke, of Vienna (1852); an excellent instrument.
16. Small level of the Starke tablet.
17. Gnomon and compass of the Starke tablet.
18. Dioptric and telescope of the Starke tablet.
19. Metrical chain of 20 mètres.
20. Odometer, by Adams, of London (1791).

Group. IV.—Levels.

1. Aneroid, by J. Goldschmid, of Zurich; where can be read an eight-thousandth part of a millimètre of movement in the sides of the box (1874).
2. Naudet's olosteric barometer, by Feigestock, of Vienna, which gives the one-tenth of a millimètre of atmospherical pressure (1874).
3. Metallic thermometer of Bourdon.
4. Naudet's olosteric barometer, by Hirsch, of Florence; gives half a millimètre of pressure (1872).
5. Naudet's olosteric barometer, by Frescura, of Padua (1873).
6. Naudet's olosteric barometer, by Feigestock, of Vienna; like No. 2.
7. Aneroid barometer, by Bourdon (1859).
8. Aneroid barometer, by Naudet; like No. 2.
9. Metallic barometer, Bourdon, from the Tecnomanasio of Milan.
10. Olosterical barometer, Naudet, by Feigestock; like No. 2.
11. Level with telescope, by Rocchetti, of Padua, with thread micrometer (1853).
12. Level with distance measurer, by Carl Starke, of the Imperial and Royal Polytechnic Institute of Vienna (1855); an excellent instrument.
13. Pendulum level with two telescopes; an historical piece; must be very old; the telescopes are not achromatic.
14. Level with telescope, by Rodella, of Padua (1820).
15. Level with mirror, rather old.
16. Level with distance measurer, by Starke and Kammerer, of Vienna (1876); an exquisite instrument.
17. Pocket level, by Carl Starke, of Vienna (1850).
18. Level with communicating tubes; an old model (1810).

3. Hydrometrical pendulum of Venturoli, constructed by the engineer Albanesi, of Venice, in 1790.
4. Model of the Cremona regulator for dispensing water.
5. Model of the Piedmontese regulator for dispensing water.
6. Model of the regulator of the Milanese Bocca Magistrale for dispensing water.
7. Ball plummet, 30 mètres long, with small brass chain for centimètres and millimètres (1860).
8. Pilot tube, modified by Mallet, length 14 mètres, with float, constructed by the Royal Observatory of Padua (1852).
9. Tachymeter, of Brünnings, constructed in the workshop of the Royal Observatory of Padua, in 1483.
10. Portable hydrometer, in several pieces, length 8 mètres, of recent construction, to take the surface of the water of rivers with perfect accuracy, whence to deduce the declivity of the superficies, and to introduce it into the hydraulic formulæ; constructed in the workshop of the Royal Observatory in 1874. The cabinet has three of them, which admirably answer the purpose.
11. Retrometrical rod, of Teodoro Bonati, of wood, composed of 10 pieces, constructed at the Royal Observatory of Padua in 1848.
12. Small mill by Woltmann, constructed in the workshop of the Royal Observatory of Padua in 1858.
13. Float, simple and compound.
14. Retrometrical Asta, of Teodoro Bonati, composed of tin tubes, 16 mètres long, divisible into 38 pieces of various lengths, constructed in 1859.
? 15. Pilot Tube, modified by Darcy, constructed by Sarran of Paris, in 1871.
16. Small mill of Woltmann, constructed in 1870, by J. Kern of Aaran, with two flyers and two wheels unequal in size.
17. Tachymeter of Brünnings, modified by Professor Turazza, constructed in the workshop of the Royal Observatory of Padua, in 1859.

4563. Photographs of Scientific Instruments in the Cabinet of Physical Science, Royal University of Padua.

Director, Prof. Rossetti.

(1.) INSTRUMENTS OF GALILEO.

a. Apparatus to demonstrate the theorem that a body falls in equal time from a chord and from the vertical diameter of a circle.

b. Telescope.

c. Atmospheric and water thermometer.

d. Natural loadstone, armed, weighs 2¼ oz., supports 100 oz.

The scale is about mill. 100 to a mètre.

(2.) INSTRUMENT for dividing by Musschenbroeck, improved by Poleni, 1740–1760.

(3.) INSTRUMENT by s'Gravesande for central force; improved by Poleni, 1740–1760.

(4.) CONDENSING ELECTROMETERS, by Prof. Salvatore Dal Negro, 1804.

These instruments are interesting, historically; upon the results obtained by them, Dal Negro disputed the theory of Volta, and established from the

[illegible] of the chemical theory of the pile. (See [illegible] a new [illegible] and some experiments in charging the voltaic [illegible] by Ab. Dal Negro [illegible], Italian Society of Science, Modena, 18[illegible]

[illegible] 1 and 2. [illegible], by Prof. Salvatore Dal [illegible] researches on the laws of weights falling freely [illegible] the thread which holds the weights suspend[illegible] [illegible] is set at liberty, which, being stopped by the [illegible] at the end of its course, cuts another thread.

3. [illegible] (See New method for measuri[illegible] [illegible] fractions of time, invented by the Ab. Dal Negro, [illegible] New Oligochronometer, Padova, 1809.)

5. [illegible], by Dal Negro, app[illegible] the measurement of the velocity of projectiles. 1. Cannon, [illegible] of [illegible] coming out of the mouth breaks a thread whi[illegible] the pendulum of the oligochronometer in motion (2). 3. M[illegible] [illegible] target, which on being hit breaks a thread which st[illegible] pendulum. 4. Details of the oligochronometer. (Se[illegible] [illegible] measuring the velocity of projectiles, 1824, by S[illegible] Dal Negro [illegible]

[illegible] Motor, by Prof. Salvator[illegible] [illegible] of a temporary m[illegible] [illegible] alternately [illegible] commutator [illegible] The [illegible] the movement of the pend[illegible] [illegible] of levers, is transformed [illegible] by Prof. A. Dal [illegible] [illegible] Royal [illegible]

[illegible] Prof. Dal Negro. [illegible] [illegible] the current is [illegible] [illegible] pendulum is [illegible] [illegible]

[illegible] Motor, by Prof. Dal Negro [illegible] [illegible] electro-magnet [illegible] [illegible] that of a [illegible] [illegible] of a weight. This movement of th[illegible]

›duces the inversion of the current in the electro-magnet, and means of a swing commutator with small cups of mercury. ee Description by Prof. Dal Negro, Padova, 1838, and in ınali delle Scienze del Regno Lombardo-Veneto, tomo VIII. nestre 1°, 1838.)

(9.) 1. MACHINE for DIVIDING. (Salleron, Paris, 1870.)
2. Cathetometer of the Tecnomanasio of Milan, improved in the ›rkshop of the Astronomical Observatory at Padua; added to it an internal counterpoise.
3. Balance of precision, by Deleuil, of Paris.
4. Quadrant Areometer, by Poleastro (1803). It is a hydro-.tic balance with quadrant. It is used to ascertain the density of ids, and is much more correct than ordinary areometers.
5. Sphærometer, by Brunner (1870).
6. Goniometer, by Babinet.

(10.) 1. MODEL of a PUMP by suction and pressure.
2. Barometer, by Poleni (1740–1760).*
3. Barometer, by Amontons.
4. Barometer, by Cassini.
5. Barometer (quadrant).
6. Barometer of Fortin.
7. Barometer of Fortin, constructed by Bellani.
8. Syphon barometer, constructed by Bellani.

(11.) 1. AIR-PUMP by suction and pressure, by Deleuil. Gives ·efaction to 2 mill., and compression to 10 atmospheres. The ect is double, and the piston does not touch the walls.
2. Differential manometer of Regnault.
3. Metallic manometer.

(12.) 1. DOUBLE SIREN of Helmholtz (Kœnig, Paris).
2. Apparatus by Kœnig for the combination of vibrating forces. ay also be used for the experiments of Lissajous.
3. Apparatus by Kœnig for the interference of sounds.
4. Organ pipes with manometrical capsules, by Kœnig.
5. Apparatus for musical flames.
6. Analyser of sounds (Kœnig).
7. Acoustic interrupter.

(13.) 1. HELIOSTAT, made at Padua in 1828 by the younger ›ssarolo, resembling, with modifications, that by Prandi. The flected ray may be thrown in any direction. (*See* Opere Scient. Bologna, 1824, p. 244, and Santini, Strumenti Ottici, vol. 1, ıdova, 1828.)
2. Heliostat of Silbermann; made at Paris.

---

* A constant level in the vessel is obtained by the immersion of a screw.

3. Lantern for electric light, with Foucault's regulator … structed by Duboscq.*

4. Lamp for oxyhydrogen magnetic light, by Carlevaris.

5. Lamp for the Drummond light.

6. Regulator for electric light, by Archereau, with refl… invented by Prof. Rossetti so as to throw the light in all dire…

(14.) 1. COMPLETE OPTICAL BANK.

2. Microscope, by Hartnack.

3. Microscope, by Amici.

4. Microscope, by Plössl.

5. Dialytic telescope, by Plössl.

6. "Lentiprisma."

7. Prism for projections.

8. Spectroscope, for direct vision.

9. Bunsen's Spectroscope.

(15.) 1. Large APPARATUS for POLARISATION, made by S…

2. Apparatus by Nörremberg.

3. Apparatus for polarisation, Biot.

4. Apparatus for polarisation, Arago.

5. [illegible], Arago.

6. Apparatus for polarisation, by Malus.

7. [illegible]

8. [illegible] by Becquerel.

… THERMOMETER, by Jolly, made at M…

… and Desormes.

… by Favre and Silbermann.

… of Melloni, made by Ruhmkorff.

… stationary STEAM ENGINE.

… by …wsky, for measuring the inte… components of terrestrial magnetism.

…

… of Lamont, made at Monaco.

… to determine all the ma…

… magnetism.

… MACHINE, by Winter, with two

… of the second kind, with horizontal … Milan.

… Ruhmkorff's. Made at Berlin.

… MACHINE of the first kind, worked by a w…

… to measure the amount o… intensity and for other exper… Macchine Elett…

* … is attached a project on microscope.

(Atti dell' Istituto Veneto, Vol. III., Ser. IV., 1874; Nuovo Cimento, Vol. XII., 1874. Ann. de Chim. et de Phys. T. IV. 1875., Journal de Physique, 1875).

(21) 1. RHEOTONU of Bréguet and Masson.

2. Sine compass.

3. Tangent compass.

4. Thermometer, Riess's.

5. Reometric Balance, Bernardi's.

A magnetic needle, working upon horizontal pivots, is surrounded by a frame, on which is wound a wire, and is united in action with the yoke of a sensitive balance. The intensity of the current traversing the wire is measured by the weight that must be placed in one of the scales of the balance, in order that the beam, and consequently the needle, may rest horizontally.

6. Galvanometer (vertical) for instruction.

7. Galvanometer of Du Bois Reymond, made by Sauerwald.

8. Torsion galvanometer.

(22.) 1. FOUCAULT'S APPARATUS for transforming heat into work by means of induced currents. Electricity.

2. Electro-magnetic motor, applied to Geissler's tubes.

3. Electro-magnetic motor, by Page.

4. Apparatus of De la Rive for the rotation of the voltaic arch.

5. Matteucci's induction coil.

6. Magneto-electric machine, by Stöhrer.

7. Dynamo-magneto-electric machine, by Ladd.

(23.) Large RUHMKORFF'S COIL, with Foucault's interrupter, and accessories; made at Paris. Gives sparks 40 centim. long.

(24.) 1. HYGROMETER, Regnault's.

2. Hygrometer, Daniel's.

3. Psychrometer.

4. Condensation hygrometer, Belli's. (*See* Belli, Elementary Course of Experimental Physics, Vol. II., Milan, 1838.)

5. Psychrometer, Belli's. (*See* Belli, Elementary Course of Experimental Physics, Vol. II., Milan, 1838.)

6. Parchment hygrometer, Bellani's.

7. Maximum and minimum thermometer, Bellani's.

8. Maximum and minimum thermometer, Walferdin's.

9. Atmidometer of Landriani, perfected by Bellani. (*See* Belli, Elementary Course of Experimental Physics, Vol. II., Milan, 1838.)

(25.) ROSSETTI'S APPARATUS for the display of luminous electric figures obtained by the discharge of positive or negative electricity upon the naked surface of a glass, the other surface of which is furnished with an armature. (*See* Di una curiosa esperienza elettrica:—Atti delle Società Veneto-Trentina di Scienze Naturali, Vol. I., 1872. Nuovo Cimento, Vols. V., VI., 1872. Carl's Repertorium der Physik, 1873. Journal de Physique, Paris, 1873, Novembre.)

4564. Photographs of Scientific Instruments in the Phy
sical Cabinet of Science, University of Pavia.

Director, Prof. Giovanni Canton

1. Small apparatus for the study of reciprocal electrical influence, with tw
electrometers. Volta.
2. Two electrophori which recharge themselves and work as unfailing source
of electricity (first example of an electric machine by induction). Volta.
3. Measurer of powerful electric tension, by Volta.
4. Apparatus for the study of the electric spark. Volta.
5. Apparatus for the dilatation of gaseous fluids. Volta.
6. Electric duplicator by Giuseppe Belli. (Attempt at an electric multipli
which served to introduce the next machine.)
7. Electric machine by induction, G. Belli. (First example of an electr
meter by induction, somewhat like the first machine of Holtz).
8. Hygrometer, with durable indications (by the same).
9. Psychrometer with bellows (by the same).
10. Collector of atmospheric heat, with continuous indications, by Co
Bellani.
11. Psychrometer with continuous indications, by Con. Bellani.
12. Balance barometer, modified by Prof. Giovanni Cantoni.
13. Normal barometer for Meteorological Stations, by Prof. Giova
Cantoni.
14. Psychrometer with ventilator, by Prof. Giovanni Cantoni.
15. Electric balance, by Prof. Giovanni Cantoni.
16. Electric scale, for the measurement of electrical adherence.
17. Maximum and minimum thermometer, by Prof. Giovanni Cantoni.
18. Anemometrograph, by Prof. Parnisetti and Ferd. Brusotti.
19. Modification of the machine of Attwood, by Ferdinand Brusotti.
20. Hygrometer worked with sulphuric acid, improved by Brusotti.

4565. Photographs of Scientific Instruments in t
Royal Observatory of Palermo. *Director, Prof. G. Cacciator*

1. Great circle by Ramsden, 1790. The principal parts are, first, a verti
axis of conic, parallelopiped form, destined to support two graduat
circles, one for altitude, the other for azimuth. 2nd. The upper support
this axis, formed of four columns with four arches, and a collar in the midd
3rd. The lower support, composed of three circles placed horizontally o
on the other. 4th. A balustrade. 5th. An achromatic telescope. 6th. Th
microscopic micrometers, with other smaller pieces. (*See* annexed descript
by Piazzi.)
2. Catalogue of the stars made by circle No. 1.
3. Equatorial, by Merz. (Aperture of object glass 9·665 inches.) Set
in 1865.
4. Spectroscopic observations by the above equatorial.
5. Seismograph of Niccolo Cacciatore, 1826. A circular receiver, p
forated laterally in eight parts, indicating the four cardinal points, and
intermediate points. Placed on a perfectly horizontal plane, and filled w
mercury which touches the holes, and which therefore can spill at the l
oscillation, and in the direction of the oscillation. A corresponding num
of small cups placed below the holes to receive the spilt mercury, wh
may afterwards be replaced. The mercury received in the cups indicates
undulatory shocks of earthquake.
6. Anemometer by Niccolo Cacciatore, 1832. Attached is a descriptio
the instrument by the inventor.

4566. Photographs of collection of **Apparatus formerly belonging to Volta.**

Liceo Volta of Como, Cabinet of Physics and Chemistry, Prof. Giovanni Gambara.

1. Small voltaic pile.
2. Small voltaic pile with circle of cups.
3. Electrophorus.
4. Two wooden discs covered with silk.
5. Electroscope.
6. Apparatus for igniting hydrogen gas by the electric spark.
7. Glass electrical pistol of Volta.
8. Eudiometer of the same.
9. Small squares of zinc and copper for generating electricity.
10. Glass tube containing mercury, for determining the coefficients of the expansion of air.
11. Small case made expressly for the protection of the above instruments.

4567. Photograph of Registering Evaporimeter, according to the last plan adopted by the inventor, Prof. Ragona.

Observatory of the Royal University of Modena; Director, Prof. Domenico Ragona.

4568. Photographs of Scientific Instruments in the Cabinet of Physical Science of the University of Naples.

Director, Prof. Giuliano Giordano.

1. Fresnel lens used by Melloni in his researches upon radiant heat, in particular with reference to the heat of the rays of the moon.
2. Floating plummet, by Paolo Anania de Luca.
3. A most accurate balance, by Bandini, machinist of the University, resembling that of Steinheil, but much less costly.

4569. Photographs and Drawings of Scientific Apparatus in the Vesuvian and Meteorological Observatory at Naples.

Director, Prof. Luigi Palmieri.

1. Portable seismograph by Palmieri, with a printed description.
2. Stationary seismograph, made by order of the Hydrographic Department of the English Admiralty, by Prof. Palmieri.
3. Stationary seismograph, made for the Vesuvian Observatory. (*See* explanatory note.)
4. Anemograph with hydrograph annexed, by Prof. Palmieri, with an illustrated description.
5. Bifilar electrometer and apparatus, with movable conductor, by the same, with two printed descriptions.

4570. Photographs of Scientific Apparatus.

University of Pisa; Director, Prof. Riccardo Felici.

Very ancient thermometer. It is impossible to say whether it works by water or alcohol. For graduation it has a string of glass beads. In the upper part are enamelled the characters, D. 20, A. 25.

II, III, IV. Galvanic chronographic interrupter, described in the [illegible] Cimento, t. xi., p. 115, and t. xiii., p. 364*. It opens and closes [illegible] electric currents, measuring the intervals of time by the diapason (d), [illegible] vibrations marks by a style the oscillations on the smoked cylind[illegible]. Perpendicular to the axis of the cylinder are eight rays, which rotate with [illegible] are furnished with small stops of steel isolated on ebonite. These, [illegible] on the [illegible], detach them from the pieces (p) opening and [illegible] the circuits. [illegible] method of closing [illegible] itself [illegible] opening. For the ordinary way of closing, the piece (g) is used, which [illegible] be found on [illegible] (see description quoted). The surfaces of contact [illegible] points of interruption are of silver, and to make them fit bet[illegible] cylinders (p) are movable on their own axis. The diapason is [illegible] around a horizontal axis [illegible], and can slide along it. The plat[illegible] [illegible] is movable around a vertical axis; the correcting screw s can [illegible] [illegible]. The screw [illegible] regulates the contact of the style with the [illegible]. The piece [illegible] which turns with the cylinder, at one point of the [illegible] [illegible] piece [illegible] the diapason. The small bar of wood [illegible] the [illegible]. The base of the apparatus is of [illegible] length 0.64, breadth 0.19 meter. The remainder is of brass, [illegible] isolating pieces, which are of ebonite.

4571. Drawing of Two Sections of the Carni[illegible] Julian Alps. [illegible] m. 0.40.

[illegible] Director. Trieste [illegible]
[illegible] and Natural Science.

[illegible] CONTRIBUTED BY THE REALE [illegible] STUDII SUPERIORI PRATICI [illegible] PERFEZIONAMENTO, FLORENCE. PRESI[illegible] COMMENDATORE SIGNOR PERUZZI.

INSTRUMENTS OF GALILEO.

Galileo's Telescope. Object glass, 50 mm. in d[illegible] [illegible] 22 mm. in diameter. It served for [illegible] and experiments of Galileo and [illegible]

Galileo's Telescope. Object glass, 3[illegible] mm. in [illegible] [illegible] diameter; made by [illegible]

Object Glass [illegible] diameter of 40 mm., **made by** [illegible] [illegible] the satellites of Jupiter [illegible]

[illegible] Cimento there [illegible] [illegible] and there [illegible]

of January 1610, and first saw the spots on the sun. Having been broken, it was presented by Viviani to Prince Leopoldo dei Medici, who placed it in a frame finely wrought in ivory, with inscriptions.

Compass of Proportion, called also military compass, **invented by Galileo** in 1596.

Natural Magnet, mounted by Galileo, weighing six ounces. He presented it to the Grand Duke Ferdinand II. dei Medici. It holds a weight of ten pounds. It is made in the shape of an urn.

Air Thermometer, in the form first given by **Galileo.**

Galileo's Microscope, then called **Occhialino.** Only the little tube remains, the lenses are wanting.

Exact copy of the **Drawing** representing the first idea of the **Application** of the **Pendulum** to the clock; **dictated by Galileo,** then blind, to his son Vincenzo and his disciple Viviani. Elucidated on the original of the Galilean manuscripts in the Biblioteca Palatina.

Instruments of the Accademia del Cimento.

Thermometer, cinquantigrade, with spherical bulb. The freezing point corresponds to 13°·5. The academicians used this thermometer for the meteorological observations instituted first by them in 1654.

Thermometer, cinquantigrade, with cylindric bulb. The point of ice melting corresponds to 13°·5.

Thermometer, settantigrade. The freezing point is at 23°·5.

Thermometer for bath. When immersed in the bath it must indicate 49°, as is written in the upper little ball.

Thermometer, with foot simple divided in 470°, corresponding to 26° centig. It served for the experiment made to ascertain whether the cold of ice reflects itself from the mirror like the heat of burning coals and light.

Thermometer, with elaborate foot. An object of art.

Thermometer in winding form, very sensitive, height 32 cm.; the spiral tube is 2·30 meters long.

Thermometer, with balls (thermoscope). The alcohol dilating by heat, the little balls fall one after another according to their weight.

and Bonaventura Cavalieri, disciples of
telescopes of Galileo, and the broken

of the tribune.—The lunette represents
Torricelli and Viviani the geometrical
of heavy bodies. The busts are those of
Viviani. The shelf contains the natural
of proportion, the design of the first
pendulum to clocks, and the first finger

of the tribune.—The lunette represents
repeats the famous experiments on the
plane. The shelves contain various
cademia del Cimento.
the tribune.—The lunette represents a
which the experiment is being made to
reflected by a mirror, like the heat of
contain ancient instruments, partly of

ancient instruments, partly belonging

Temple of the **Nebula** of
first months of the present year,
of Amici.

SECTION 21.—MISCELLANEOUS.

West Gallery, Upper Floor, Room (O)

PORTRAITS AND RELICS.

4572. Sir Isaac Newton. Portrait engraved by J. Outrim. From the original drawing in the Pepysian Collection at Cambridge. *Robert James Mann, M.D.*

4572a. Photographic Copy of an early portrait of **Galileo.** *J. Norman Lockyer, F.R.S.*

BOOKS.

4573. The Works of Van Marum, and the three volumes already issued of the Archives du Musée Teyler.
Foundation Teyler at Haarlem.

[illegible] instruments that are shown, and in order to give [illegible] idea of the [illegible] machine and the chemical apparatus which con[illegible] the works of Van Marum "Machine Electrique" (thr[illegible] [illegible] (one volume), containing the e[illegible] [illegible] are sent.

The [illegible] Archives du Musée Teyler" contain the refr[illegible] [illegible] determined by Prof. Van der Willigen; [illegible] various specimens of crown and flint-glass by P[illegible] [illegible] and drawings, by Conservator Dr. Winkl[illegible] [illegible] palæontological objects, &c.

4574. Manuals and Treatises on method of instruction [illegible] of Natural History, adopted by the military schools [illegible]
[illegible] of the Pedagogical Museum, Rus[illegible]

4574a. List of Publications.
Messrs. Macmillan and Co., Lon[illegible]

[illegible]
[illegible] M.A., LL.D., D.C.L., Astronomer Royal, &[illegible]
[illegible] theory of errors of observation.
[illegible] Popular astronomy. On sound and at[illegible]
[illegible] By R. S. Ball, M.A.
[illegible] By H. Charlton Bastian, M.D., F.R.S.

Rudiments of physical geography for the use of Indian schools, and a glossary of the technical terms employed. By Henry F. Blandford, F.G.S.

First principles of chemical philosophy. By Josiah P. Cooke, junior, Ervine Professor of Chemistry and Mineralogy in Harvard College.

Cave Hunting. Researches on the evidence of Caves, respecting the early inhabitants of Europe. By W. Boyd Dawkins, F.R.S., Director of the Museum and Lecturer on Geology in Owen's College, Manchester.

An introduction to the Osteology of the Mammalia. Being the substance of the Course of Lectures delivered at the Royal College of Surgeons of England in 1870. By W. N. Flower, F.R.S., F.R.C.S., Hunterian Professor of Comparative Anatomy and Physiology.

Pharmacographia. A history of the principal drugs of vegetable origin found in commerce in Great Britain and British India. By F. A. Flückiger and D. Hanbury, F.R.S.

The Elements of Embryology. By Michael Foster, M.D., F.R.S. and F. M. Balfour, M.A., Fellow of Trinity College, Cambridge.

Meteorographia, or Methods of Mapping the Weather. By Francis Galton, F.R.S.

Hereditary Genius; an Inquiry into its Laws and Consequences. By Francis Galton, F.R.S.

English Men of Science, their Nature and Nurture. By Francis Galton, F.R.S.

An Elementary Treatise on the Lunar Theory, with a brief Sketch of the Problem up to the time of Newton. A Treatise on Astronomy, for the use of Colleges and Schools. By Hugh Godfray, M.A.

The Forces of Nature. A popular Introduction to the Study of Physical Phenomena. By Amédée Guillemin. Translated from the French by Mrs. Norman Lockyer; and edited with Additions and Notes, by J. Norman Lockyer, F.R.S.

The Student's Flora of the British Islands. By J. D. Hooker, C.B., F.R.S., M.D., D.C.L., President of the Royal Society.

A Treatise on Ornamental and Building Stones of Great Britain and Foreign Countries. Arranged according to their Geological Distribution and Mineral Character, with illustrations of their application in Ancient and Modern Structures. By Edward Hull, M.A., F.R.S., Director of the Geological Survey of Ireland, &c.

Lessons in Elementary Physiology. By T. H. Huxley, LL.D., F.R.S., Professor of Natural History in the Royal School of Mines. Lay Sermons, Addresses, and Reviews. By T. H. Huxley, LL.D., F.R.S., Professor of Natural History in the Royal School of Mines.

A Course of Practical Instruction in Elementary Biology. By T. H. Huxley, LL.D., Sec. R.S., assisted by H. N. Martin, B.A., M.B., D.Sc. Fellow of Christ's College, Cambridge.

Elementary Lessons in Logic: Deductive and Inductive. With copious Questions and Examples, and a Vocabulary of Logical Terms. By W. Stanley Jevons, M.A., F.R.S., Professor of Logic in Owen's College, Manchester.

The Principles of Science. A Treatise on Logic and Scientific Method. 2 vols. By W. Stanley Jevons, M.A., F.R.S., Professor of Logic in Owen's College, Manchester.

The Owen's College Junior Course of Practical Chemistry. By Francis Jones, Chemical Master in the Grammar School, Manchester. With Preface by Professor Roscoe.

Journal of Anatomy and Physiology. Conducted by Professors Humphry and Newton, and Mr. Clark of Cambridge, Professor Turner of Edinburgh, and Dr. Wright of Dublin. Vols. 8 and 9.

Introduction to Quaternions, with [illegible] M.A., F.R.S., and P. G. Tait, M.A., Pr[illegible] matics in the University of Edinburgh.

Researches on the Solar Spectrum [illegible] Elements. By G. Kirchoff, of Heidelbe[illegible] F.R.S.

Elementary Lessons in Astronomy [illegible] By J. Norman Lockyer, F.R.S.

The Romance of Astronomy. By [illegible] Assistant Tutor of St. Peter's College, [illegible]

Lessons in Elementary Anatomy. By [illegible]

Nature [illegible]

The Spectroscope and its Application[illegible]

The Origin and Metamorphoses of In[illegible] F.R.S.

The Birth of Chemistry. By G. F. [illegible]

The Transit of Venus. By G. Forbe[illegible] sophy in the Andersonian University, G[illegible]

The Common Frog. By St. George [illegible]

Polarisation of Light. By W. Spotti[illegible]

On British Wild Flowers, considered [illegible] Lubbock, M.P., F.R.S.

Newton's Principia. Edited by Pro[illegible] fessor Blackburn.

Lessons in Elementary Botany. B[illegible] [illegible] of Botany in University College, [illegible]

First Book of Indian Botany. By D[illegible] of Botany in University College, Lond[illegible]

[illegible] Method of Predicting by gra[illegible] [illegible] and Solar Eclipses [illegible] [illegible] Methods for the Accura[illegible] C. Penrose, F.R.A.S.

An Elementary Treatise on Steam. [illegible] Whitworth Scholar, &c., [illegible] C[illegible]

Elements of Physical Manipulation. [illegible] Professor of Physics in the Massachuset[illegible]

Primers

Chemistry. By H. E. Roscoe, F.R.S. [illegible] College, Manchester.

Physics. By Balfour Stewart, F.R.S. Owens College, Manchester.

Physical Geography. By A. Geikie, [illegible] of Geology and Mineralogy in the Unive[illegible]

Geology. By Professor Geikie, F.R.S[illegible]

Physiology. By Michael Foster, M.[illegible]

Astronomy. By J. N. Lockyer, F.R.[illegible]

Botany. By J. D. Hooker, C.B., F.[illegible]

The Theory of the Glaciers of Savoy. [illegible] ated by A. W[illegible] Q.C., late President [illegible] added the Original Memoirs, and Supple[illegible] Tait and J. Ruskin. Edited, with Intro[illegible] B.A., Professor of Natural Philosophy [illegible] gow.

A System of Medicine. Vol. I. Edited by J. Russell Reynolds, M.D., F.R.C.P., London. Part. I. General Diseases, or Affections of the whole System. Part II. Local Diseases, or Affections of particular Systems. Vol. II. Part. II. Diseases of the Nervous System. (*a.*) General Nervous Diseases. (*b.*) Partial Diseases of the Nervous System. I. Diseases of the Head. II. Diseases of the Spinal Column. III. Diseases of the Nerves. II. Diseases of the Digestive System. (*a.*) Diseases of the Stomach. Vol. III. § II. Diseases of the Digestive System (continued). (*b.*) Diseases of the Mouth. (*c.*) Diseases of the Fauces, Pharynx, and Œsophagus. (*d.*) Diseases of the Intestines. (*e.*) Diseases of the Peritoneum. (*f.*) Diseases of the Liver. (*g.*) Diseases of the Pancreas. § III. Diseases of the Respiratory Organs. (*a.*) Diseases of the Larynx. (*b.*) Diseases of the Thoracic Organs.

Lessons in Elementary Chemistry, Inorganic and Organic. By Henry E. Roscoe, F.R.S., Professor of Chemistry in Owen's College, Manchester.

The Spectrum Analysis. A series of lectures delivered in 1868, with four appendices. Third edition, with the most recent discoveries and additional illustrations. By Henry E. Roscoe, F.R.S., Professor of Chemistry in Owen's College, Manchester.

A Manual of the Chemistry of the Carbon Compounds, or Organic Chemistry. By Schorlemmer, F.R.S.

Lessons in Elementary Physics. By Balfour Stewart, F.R.S., Professor of Natural Philosophy in Owen's College, Manchester.

Recent Advances in Physical Science. By Professor P. G. Tait.

Sound and Music. A Non-mathematical Treatise on the Physical Constitution of Musical Sounds and Harmony, including the chief Acoustical Discoveries of Professor Helmholtz. By Sedley Taylor, M.A., late Fellow of Trinity College, Cambridge.

Papers on Electrostatics and Magnetism. By Professor Sir W. Thompson, F.R.S.

The Depths of the Sea. By C. Wyville Thomson, LL.D., F.R.S., &c., Director of the Scientific Staff of the "Challenger" Exploring Expedition.

A History of the Mathematical Theories of Attraction and the Figure of the Earth, from the time of Newton to that of Laplace. By Isaac Todhunter, M.A., F.R.S.

Contributions to the Theory of Natural Selection. By Alfred Russell Wallace.

Prehistoric Annals of Scotland. 2 vols. By Daniel Wilson, LL.D., Professor of History and English Literature in University College, Toronto.

Prehistoric Man. 2 vols. By Daniel Wilson, LL.D., Professor of History and English Literature in University College, Toronto.

4574b. Collection of Scientific Books.

Messrs. Longmans.

PLANS AND DRAWINGS.

4575. Three Plans of Sir Josiah Mason's College of Science at Birmingham. Ground plan, Ground floor, and Second floor.

George Gore, F.R.S.

4576. Collection of Plans and Programmes of Foreign Laboratories, &c. *George Gore, F.R.S.*

1. Das Neue Chemische Laboratorium, zu Berlin, von Albert Cremer. Mit 12 Kupferdrucktafeln. Berlin, Verlag von Ernst D. Korn, 1868.

2. Die Polytechnische Schule zu Aachen, entworfen von Robert Cremer, ausgeführt und herausgegeben von Ferdinand Esser. Mit 11 Kupfertafeln. Berlin, Verlag von Ernst D. Korn, 1871.

3. Das Chemische Laboratorium der Universität Greifswald, von G. [illegible] Mit 4 Kupfertafeln. Berlin, Verlag von Ernst D. Korn, 1864.

4. A M. Kir. Egyetem Vegytani Intézetének Leirasi (ot Tablával). Than Karoly. Pesten, Eggenberger Ferdinand M. Tud. Akad. Köngvárusnál [illegible] mann es Molnar, 1872.

5. Das Chemische Laboratorium der K. Ungarischen Universität in Pest, von Dr. Carl von Than. Mit 5 zinkografischen Tafeln. Wien, 1872, Wilhelm Braumüller.

6. Programm der K. K. Technischen Hochschule in Wien, für das Studienjahr 1873-4. Verlag der K. K. Technischen Hochschule von L. W. Seidel & Sohn, Wien, 1873.

7. Das Neue Chemische Laboratorium der Universität Leipzig, von Hermann Kolbe. Mit einen Situationsplan in Lithographie und 7 Holzschnitten. Leipzig, F. A. Brockhaus, 1868.

8. Programm der Polytechnischen Schule zu Aachen für den Cursus 1871– Verl. von J. Stercken. Aachen.

9. Das Landwirthschaftliche Studium an der Universität Göttingen, von Gustav Drech[illegible] Mit 4 lithtafeln, Göttingen, 1872. Deuerlichsche Buchhandlung.

10. Über das Physiologische Privat Laboratorium an der Universität Leipzig, von Johann N. Czermak. Mit 5 Holzschnitten, Leipzig. Verlag [illegible]

4576a. Programme of Polytechnic School, Carlsruhe, 1871 [illegible] *George Gore, F.R.*

4576b. Programme of Polytechnic School, Aix-la-Chapelle, 1872. *George Gore, F.R.*

4576c. Higher Polytechnic Instruction in Germany, Switzerland, France, Belgium, and England, 1873. [illegible] *George Gore, F.R.*

4576d. Order of Study, Polytechnic School, Carlsruhe, 1869. *George Gore, F.R.*

4576e. Polytechnic School, Hanover, 1856. *George Gore, F.R.S.*

4576f. Ground Plan of the University of Leipzig. *George Gore, F.R.S.*

4576g. Personal Register of the University of Leipzig, 1872. *George Gore, F.R.S.*

4577. Plans of Chemical Laboratories at the Owens College, Manchester. *Alfred Waterhouse*

[illegible] The chief features of the building are two [illegible] each [illegible] ft. long, 30 ft. broad, and 29 ft. high. No. [illegible] the first year's qualitative students. In this there are

60 working places. No. 2 (Fig. 1) is arranged for the advanced or quantitative students, and contains ten blocks of four benches, each for the accommodation of 40 students.

The first essential in a laboratory, that of good light, is provided for by large windows and skylights on both sides. The other essential, that of plenty of air and good ventilation, is secured by lofty rooms having cubic contents of upwards of 50,000 ft., and by means of the powerful draught of a high chimney at one end of the laboratory block; the upward current being maintained by means of a furnace in the basement at the foot of the chimney, which furnace in the winter works the hot water heating apparatus, and in the summer simply serves for ventilating purposes.

The ventilation of the laboratory may be divided into two kinds, (*a*) the general ventilation, and (*b*.) the special ventilation. (*a*) The general ventilation is effected by a wooden perforated ceiling running the whole length of both of the main laboratories, and conveying the vitiated air by a large air-trunk to the shaft, within which rises the smoke flue of the furnace. The supply of fresh air is obtained from a high level by a fresh air shaft, down which the air passes, the hot water pipes being drawn by the aspiration of the chimney into the laboratories through gratings placed in the walls. This ventilation acts so successfully, that although no less than 44 beginners are now working in the qualitative (No. 1) laboratory, and 42 advanced students are working in the quantitative (No. 2) laboratory, still the air in both rooms is clear and pleasant throughout the day. In case, through negligence or accident, a large escape of acid fumes should occur, the windows being hung on pivots, can all be opened, and a thorough renewal of the air be effected in a few minutes. (*b*) The special ventilation is also worked by the main shaft, and is divided between the evaporating niches in the walls shown in plan, and in detail in Figs. 13 to 21, and the sulphuretted hydrogen closets marked A in the detailed drawing on each working table. Each of the niches is provided with an upright glazed earthenware pipe, 4 in. in diameter, running into a horizontal pipe of the same material, 12 inches in diameter, communicating directly with the main chimney, the draught in which is powerful enough to draw air from each one of the niches without the necessity of any gas flame being used for aspiration, and no escape is noticed in the working of these when any fumes, even of sulphuric acid, are evaporated in any quantity. In order to prevent the condensation of acid liquors, or of water, when these substances are boiled in the niches, a porcelain funnel is introduced into the lower part of the earthenware pipe inside the niche; all vapours generated under this funnel are immediately swept into the chimney, and no condensation whatever takes place inside the glass windows of the niche. One of these porcelain funnels is placed in the exhibition. The amount of air which in actual practice is found to pass up these draughts, is as follows:—

The large niches at the west end of the laboratory, aspirate 100 cubic ft. of air per minute, and each of the smaller ones in the three walls running east and west, 12 cubic ft. of air per minute.

The sulphuretted hydrogen closets in each working bench, shown in section in Fig. 11, and in plan in Figs. 7 and 9, are joined together in groups of two or four, and placed in connexion with a 7 in. or $4\frac{1}{2}$ in. glazed earthenware pipe communicating with a horizontal flue shown in section in Fig. 5, running between the fireproof arching under the floor, and passing into the chimney at the point (S), Fig. 1. The down draught in each of these closets is continuous and powerful, each closet in the laboratory No. 1 aspirating at the rate of 5 cubic ft. per minute, whilst those in laboratory No. 2 aspirate on an average 20 cubic ft. per minute, those at the furthest end of the laboratory differing but slightly from those situated nearest to the chimney. The details

[illegible] arrangements of the working benches are seen in Figs. 6 to [illegible] [illegible] of buildings shown in section in Fig. 5, and on plan in F[illegible] [illegible] floors, each containing seven rooms divided into [illegible] analysis room; 3 and [illegible], balance rooms, [illegible]; 6, Prof. Schorlemmer's lecture theatre for [illegible]; [illegible] Prof. Schorlemmer's private room.

[illegible]—1, laboratory for medical studen[illegible] [illegible], also ventilated by the main shaft; [illegible] [illegible], also in connection with th[illegible] [illegible] room; 5, lavatory and cloak r[illegible] [illegible] room; 8, dark room for phot[illegible] [illegible] rooms.

[illegible] Professor Roscoe's private room, [illegible] laboratory with window opening into lab[illegible] [illegible]

[illegible] that the block of working laborator[illegible] [illegible] with the large chemical lecture theatre (o[illegible] [illegible], which has a small laboratory for the [illegible] [illegible]

[illegible] Drawings of the Lecture Table in the Th[illegible] the Royal College of Science, Dublin. *Prof. W. F. B[illegible]*

[illegible] Plan of the Laboratory of Physics of th[illegible] [illegible] University of St. Petersburg, with [illegible]

Imperial University, St. Pete[illegible]

[illegible]

APPENDIX.

APPENDIX.

24b. Cabinet, containing tablets for making mathematical calculations. *Archæological Museum, Madrid.*

Rose wood cabinet, inlaid with ivory. In three divisions are thirty small drawers, containing ivory plates with numbers and divisions to make mathematical calculations. In the inside are the arms of the monastery of the Escorial. Milanese work of the 16th century.

28b. Original Calculating Machine, known as "Napier's Bones." *Lord Napier and Ettrick.*

One of the earliest attempts to construct a calculating machine, made by John Napier, the inventor of logarithms. His method of calculating by rods was published in a volume (which is exhibited with the machine) at Edinburgh in 1617. The apparatus was commonly known as "Napier's Bones."

69e. Patent Dotting Pencil.
E. O. Richter and Co., Chemnitz, Saxony.

The arrangement is as follows :—
A small toothed wheel adapted to the kind of dotted lines to be drawn is attached to a plate, which, rolling on the paper, lifts a lever, which is again dropped by means of a spring. Attached to this arm is a drawing-pen, easily adjustable, by means of a hinge, to the correct position suited to the wheel. The wheel itself is held in position by a small, somewhat elastic plate, which can be displaced a little for fitting the different reserve wheels on which the kind of lines to be drawn depends.

69f. Patent Compasses with stationary centre point.
E. O. Richter and Co., Chemnitz, Saxony.

These compasses differ from others, chiefly by the centre-point being stationary on the paper, so that the tracing-pen, resting on the paper by its own gravity, moves about the centre-point as axis, whilst the movable pen can be displaced, without removing the compasses from the paper. By these advantages speedy and neat tracing will be achieved, even when the smallest circles are to be drawn.

69g. Patent Compasses, with drawing pen and leaden tube.
E. O. Richter and Co., Chemnitz, Saxony.

69h. Patent Diamond Compasses.
E. O. Richter and Co., Chemnitz, Saxony.

69i. Patent Diamond Compasses with drawing pen.
E. O. Richter and Co., Chemnitz, Saxony.

[redacted]

[illegible]

e surface (3):—
are in the direction of the vibrations of the two polarized
.
ace (2).
s (2):—

$$ve \begin{cases} x = a \sin 2\theta \text{ (vertical).} \\ y = b \sin 3\theta \text{ (horizontal).} \\ z = c \cos 5\theta \text{ (perpendicular to paper).} \end{cases}$$

$$ve \begin{cases} x = a \sin 2\theta. \\ y = b \sin 3\theta. \\ z = c \sin 7\theta. \end{cases}$$

n octahedron.

Image Stereoscope for showing the above.

Prof. Clerk Maxwell.

aces his eyes about two feet from the large lens, and sees ges of the figures at or near the surface of the lens.

worth's Fluid Compressed Steel.

Sir Joseph Whitworth & Co., Limited.

ast from a "Siemens'" furnace and compressed while in is metal when forged is used for Whitworths' guns, screw ings for steam engine cylinders, crank shafts, &c. &c.

cal Hydraulic Testing Machine.

Sir Joseph Whitworth & Co., Limited.

s used for testing the tensile strength of metals; the cylindrical, the central part being two inches long, and ional area of ·5 of a square inch.

el of an Ancient Egyptian Standard Cubit,
gn of King Horus, 9th Pharaoh of the 18th dynasty

Mrs. Chisholm.

ndard measure, of which this is a copy, was found in the and is now in the Royal Museum at Turin. It is a Royal ms or 28 digits. The total length of this end standard millimetres or 20·6 inches, and agrees very nearly with that ncient Pharaonic cubits still existing, as well as with the l cubit as deduced by Sir Isaac Newton from the dimensions mid, the mean length being 525 millimetres. The original ubit of a man, of 6 palms is also marked upon this measure, millimetres or 18·24 inches, and also the ancient Egyptian $\frac{2}{3}$ of the natural cubit, and equal to 12·16 inches, or 1·013 great span of 14 digits and the small span of 12 digits are

ometrical Divisions in English and Metric

Dumoulin Froment, Paris.

aston's Single Lens Micrometer.

ton Collection, Cavendish Laboratory, Cambridge.

813, p. 119.)

...ridio-platinum **Standard Metre,** in course of ...s. *Johnson, Matthey, and Co.*

...c. **Section of Metre** when finished, showing the form ...ained upon by the International Commission.
Johnson, Matthey, and Co.

278a. Magneto-Electric Water Level Indicator.
Siemens and Halske, Berlin.

A float which rises or falls with the le... of the water in the reservoir or ...nk communicates motion by a metall... chain to a magneto inductor, which ...nerating electric currents, works ... distance an indicator connected by ... cable or insulated wire.

319a. Casts of a Colle... of Roman Measures to hold ...uids. *...chæological Museum, Madrid.*

The originals, of alabaster, are ... ed at the Archæological Museum of Madrid. They ... of the last century in the Torre del ...ar, Province of ...

332a. Series of standard Measures of Capacity, in copper, with glass discs, measuring from the centilitre to the double decalitre. (11 measures.)
Messrs. Collot Brothers, Boulevard de Montrouge, Paris.

331a. Pamphlet. "Procedimientos mecanicos de cubicacion." 4to. Madrid, 1876. *Don Eduardo Saavedra, Madrid.*

Sr. Saavedra explains in this pamphlet the method adopted by him in taking out quantities for the projected railroads of the central Spanish Pyrenees.

344a. New description of Balance of Precision, designed by M. Mendeleef, Professor of the University of St. Petersburgh, and constructed by Oertling. It is more particularly described in Appendix 10 to the Ninth Annual Report of the Warden of the Standards. *H. W. Chisholm.*

The peculiarity of this balance is that it has very short arms, and thus occupies very little room, and by its more rapid motion time is saved in weighings, whilst it gives results of weighings quite as accurate as those given by balances of precision with arms of greater length as ordinarily used.

Though constructed to carry a kilogram in each pan, the total length of the beam of this balance is less than 4½ inches, whilst it is intended to give results with one tenth of a milligram. The balance beam to carry a kilogram is ordinarily 20 inches in length.

It can be used as a vacuum balance, as well as for weighings in air.

344b. Balance of Precision for minute weighings of 10 grains and under in each pan, constructed by Oertling.
H. W. Chisholm.

The beam is made as light as possible, and unusually so. The pans and suspending wire are of aluminium. The balance works upon fine points. A single action lowers the support of the beam and the supports of the pans.

346a. Series of Massive Copper Weights, standards of 1 gramme up to 20 kilogrammes, with subdivision in platina. Nécessaire for inspector of weights and measures on his rounds, weighing about 10 kilos, and containing every requisite for testing scales, of weights, measures of capacity, and of length, and for stamping.

Messrs. Collot Brothers, Boulevard de Montrouge, Paris.

346b. Ancient French Standard Weight of the city of Rouen, of brass, in the form of a series of cup weights in a closed box of ornamental shape, weighing altogether 8 lbs. of the old poids de marc de Charlemagne. Presented to the Standards Department in 1869 by Colonel Le Contens, Viscount of Jersey.

H. W. Chisholm.

346c. Weight, wrought iron, ornamented with arabesques. flowers, and masks. Made for the old Mint at Madrid in the 17th century by the iron-master *Salinas.*

Archæological Museum, Madrid.

354a. Model Balance, with two columns, specially intended for verifying the standard kilogram weights, mounting and tongue of bronze aluminium, tires and scales of aluminium, riders carriage for shifting the weights from one scale to the other, rests for four weights, rules of deposit for small sliding weights, replacing the divisional series of the gramme, such as the decigramme, centigramme, milligramme, 10th of milligramme, hand of aluminium with double dial, parallel mirror for reading the oscillations at a distance, spherical level, two "Baudin" thermometers.

Messrs. Collot Brothers, Boulevard de Montrouge, Paris.

354b. Model Balance, with two columns, of 300 grammes range, for chemical analysis, mounted on cast-iron tripod, mounting and tongue of bronze, platina tires, riders showing tenths of the milligramme, spherical level.

Messrs. Collot Brothers, Boulevard de Montrouge, Paris.

381a. Corn Balance, in box. *L. Casella.*

392a. Bullion Scales. The property of the Conservatoire des Arts et Métiers by gift, 1866 ; constructed by Baron Séguier.

The late Baron Séguier, Membre de l'Institut.

407b. Electric Chronograph. *Dr. Werner Siemens.*

This instrument, which was described in the year 1845 in Pogg. Ann. (Bd. 66, p. 435), serves for the measurement of high velocities, especially those of projectiles both along the barrel and in their further flight, and also that of electricity.

It is based on the circumstance that an electric spark leaves a sharp mark on polished steel, and that this mark can easily be discovered when the cylinder has been previously blackened. The cylinder is turned rapidly by clockwork, and each hundredth revolution is marked by the stroke of a small bell. By means of a regulator the rapidity of rotation is so arranged that the stroke of the bell coincides exactly with the beat of a second pendulum; the counting is made with a microscope with cross wires, the clockwork being stopped. The graduation of the micrometer head gives 0·0001 of a revolution of the cylinder or millionths of a second if the cylinder rotates 100 times a second, and the tenth part or ten millionth of a second can be estimated.

The measurement of the velocity of projectiles is effected by the passage of an electric spark at the moment when the projectile touches an insulated wire which reaches to the inside of the gun, and thus is free from retardation caused by the inertia of matter or magnetism.

The same apparatus can be used for the measurement of the velocity of electricity in suspended wires.

The complete apparatus comprises a Leyden jar, induction coil, commutator, gun barrel, chronograph, and two batteries.

407c. Recording Cylinder, with original marks by which the speed of electricity in iron wires has been measured.

Dr. Werner Siemens.

These marks which are surrounded by a halo or circle indicate the commencement [illegible] the discharge, the successive series of small marks has been [illegible] which has traversed the conductor, the angular [illegible] mark and the first point of the series [illegible] speed of electricity. By measurement of the [illegible] to pass through lines of various lengths [illegible] which is proportional to the square of the length [illegible] has been [illegible]. By these researches it has been shown [illegible] in conductors with a constant velocity which is [illegible], and which for iron amounts to about [illegible] per second.

[illegible] der Kgl. Pr. Acad. der Wissenschaften, 6 Dec [illegible]

408a. Current Meter.

Benjamin Theophilus Moore, M.A.

[illegible] the velocity of running water at any depth [illegible] accuracy and facility.

[illegible] brass bars united in front to a solid ogival [illegible] direction, in a double vane or tail. It [illegible] by a stirrup.

[illegible] cylinder which is provided with six screw [illegible] pivots at its extremities. This cylinder [illegible] glass tube within which is a simple train of mechanism [illegible] made by the cylinder. This train of mechanism [illegible] manner, that it remains at rest while the [illegible] the number of revolutions are [illegible] the cylinder. When the instrument [illegible] attached to the stirrup, the frame [illegible] which the axis of the revolving cylinder is [illegible] stream, the cylinder is set in motion, and [illegible] under water, by means of a spring, operated [illegible]

For use in very deep water a simple automatic starting and stopping apparatus is placed inside the water-tight compartment of the cylinder, which operates in such a way that while the instrument is descending or ascending in water, the mechanism does not record the revolutions of the cylinder, but only while it is at the depth at which the velocity is required. In this case the spring is removed and one cord only is used.

409b. Deep Sea Current Indicator.

Benjamin Theophilus Moore, M.A.

This instrument is intended to be used for the purpose of ascertaining the direction of submarine currents.

It consists mainly of a water-tight globular shell of gun metal pointed in one direction, and terminating in the other in a long double vane, and is carried by two pivots on a stirrup. Within the shell is a brass box, suspended by gimballs in the manner of a ship's chronometer, and containing a magnet with a graduated ring, and a train of clockwork. When the instrument is lowered into deep water, its principal axis takes the direction of the current, while the magnet settles itself in the magnetic meridian, after the magnet and the instrument have taken up their respective positions, the clockwork suddenly fixes the magnet at a known time. The instrument is then drawn up out of the water and opened, when the fixed magnet shows the direction, or bearing, of the current below.

This bearing is shown directly by the instrument when it is suspended from a fixed platform, or from a ship at anchor, or otherwise at rest. When the ship is in motion the instrument is to be used in combination with the deep sea current meter, by which means the velocity and direction of the submarine current can be determined simultaneously by a simple geometrical construction.

415b. Fare and Distance Indicator for Street Cabs.

Robert Foster, Sunderland.

This is an instrument for measuring the distance travelled by a cab or other vehicle to which it may be attached. A driving band taking its motion from the road wheel actuates counting wheels, and so pointers are made to indicate on dials the distance passed over and the fare. There is also an appliance for registering on a slip of paper all the fares taken during the day. The pointers can be brought back to zero by the driver, but they cannot be moved forward except by the motion of the vehicle.

421c. Gravimeter. An instrument for the measurement of the variations of the earth's attractive force, invented by J. A. Broun, F.R.S., and constructed from his drawings by Dr. C. S. Müller, of Stuttgart. *J. Allan Broun, F.R.S.*

The instrument consist of a weight suspended by two gold wires; a single wire fixed to the top of the weight and passing through its centre carries a cylindrical lever; when the lever is turned through 360° at the normal (say southern) station the torsion of the single wire thus produced carries the weight round through an angle of 90°. The forces then in equilibrium are, the torsion at force of the single wire and the attraction of the earth on the weight, which, as the two wires are no longer vertical, has been slightly raised and seeks to attain its lowest point.

On proceeding from a southern to a more northerly station the earth's attraction increases; the amount of this increase which may be measured in two ways :—

manner, so that the fixed points cannot vary. All the suspended apparatus is electro-gilt.

430a. Photograph of Electrodynamometer. Made by Professor H. A. Rowland, John's Hopkins University, Baltimore, on the model of that of the British Association.

Cavendish Laboratory, Cambridge.

484a. Two Hour Glasses. These were used in Spanish men-of-war at the beginning of the last century.

Ministry of Marine, Madrid.

484b. Chronometer, the fifth made by the English maker Arnold. It was used on board one of the Spanish ships at the battle of Trafalgar. *Ministry of Marine, Madrid.*

505. Discussion on Electro-ballistic Apparatus.

539e. An Apparatus for the Graphical representation of Two simultaneous Oscillations inclined to each other.

544b. Apparatus to illustrate **Waves** and **Nodal Vibrations** of a row of **Mutually Influencing Particles.**

Sir William Thomson.

Each particle has only one degree of freedom, and is influenced by a force depending only on the relative positions of itself and of its next neighbours on each side. The shorter the wave-length the smaller the velocity of propagation of the wave.

The apparatus consists of a series of light rods loaded at each end, and strung transversely on two threads which form a bifilar suspension placed equidistant from the centre of gravity of each rod. The distance between the threads at any point is inversely proportional to the square root of the tension at that point.

564b. Kinematic Compasses with Three Branches, designed by Reuleaux.

Royal Academy of Industry, Berlin, Director, Prof. F. Reuleaux.

By means of this instrument it is easy when the orbs of two points of a system are given, to find all the other curves of the same system.

(See Reuleaux's "Kinematik," s. 24, and following.)

The third branch of these compasses may be altered longitudinally, and is, besides, provided with a joint, so that entirely obtuse angular triangles (amblygons) as well as entirely acute-angled triangles (oxygons) can be taken by the compasses, for which the three-branched compasses of older construction were not adopted.

These compasses were manufactured by J. Kern, mechanical instrument maker at Aarau, Switzerland, by order of he exhibitor.

585a. Objects lent by **M. Golaz,** 24, Rue des Fosses, St. Jacques, Paris :—

Regnault's Eudiometer; Regnault's apparatus for measuring the co-efficient of expansion of gas; Fabre and Silbermann's

[illegible]meter; Regnault's apparatus for specific heat of g[illegible] Ja[illegible]'s Calorimeter; Bunsen's Absorptiometer; Regnault's [illegible] Thermometer; Regnault's apparatus for specific heat of liqui[illegible] Regnault's apparatus for determining the tension of steam at h[illegible] pressure. Regnault's apparatus for determining the tension [illegible] vapour from 0° to 100°; apparatus for compression of liquids [illegible] Regnault's Piezometer; Doyère's gas analysis apparatus; Doyè[illegible] Pipette for gas analysis apparatus; Favre's Mercury Calorime[illegible] Regnault's apparatus for estimating the specific gravity of [illegible] bodies.

6[illegible]0. Air Pump, by Spencer, of Dublin. *Prof. W. F. Ba[illegible]*

This air pump has no valves between the barrels and the receiver, [illegible] it is free from [illegible] of air, and is capable of making a vacuum [illegible] equal to that [illegible] by means of Sprengel's air pump. The ends of [illegible] pistons and barrels are conical, and, when they are in contact, no [illegible] remains. All the air in the barrels is therefore expelled at each stroke o[illegible] piston: the effect is the same when it is highly rarefied. The hori[illegible] position of the pump admit of the barrel being brought into close cont[illegible] with the plate, and leaves the valves accessible for cleaning or repairs.

679. Alcohol-meter.

Siemens Brothers and Co., Charlotten[illegible]

[illegible] the quantity of spirit [illegible] [illegible] absolute alcohol contained in that [illegible] [illegible] the drum imparting motion to a co[illegible] [illegible] which reg[illegible] [illegible] The measurement is unaffected either by the [illegible] [illegible] by the friction of the bearings of the spindles [illegible]

680a. [illegible] Portable Spireometer. *E. Cetti [illegible]*

697a. Stand and Burner for Sensitive Flames.

Professor W. F. Ba[illegible]

[illegible] flame [illegible] illustration of resonance. The vibrations acc[illegible] [illegible] the flame itself would emit when [illegible] [illegible] to the verge of roaring by a [illegible] [illegible] gas supply. The flame is then [illegible] [illegible] vibration will then produce the [illegible] [illegible] increase in the gas pressure [illegible] must be fed with gas which [illegible] [illegible] A large gas holder is far better than [illegible] pressure. The gas taps must be op[illegible] [illegible] weights on the gasholder. The [illegible] [illegible] and the best burner is a steati[illegible] [illegible] it gives the *tallest possible* [illegible] [illegible] Such a flame with good gas [illegible] [illegible] the influence of a sound to [illegible] [illegible] burner and pressure the quantity [illegible] determined by the degree of sensitiveness of the flame

697b. Suitable source of Sound for experiments with Sensitive Flames. *Prof. W. F. Barrett.*

This is simply a loud ticking watch enclosed in a padded case with a movable cover, and mounted on a sliding stand.

697c. Practical application of Sensitive Flames. *Prof. W. F. Barrett.*

By using a suitable burner a sensitive flame can be made to spread out sideways into a fish-tail flame under the influence of sound. Under such conditions the flame touches the compound metallic ribbon, which curves by unequal expansion, closes an electric circuit, and rings an electric bell. An arrangement of this kind could be adapted to detect burglars, or to act as a self-recording phonoscope. First exhibited by Prof. Barrett at the Royal Dublin Society, January 1868.

787a. Electro-Diapasons, showing the composition of vibratory movements by producing fixed acoustic figures. *M. Mercadier, Paris.*

816j. Wollaston's original periscopic Camera Lucida. *See* Tilloch, xxvii. (1807), p. 343 ; Phil. Trans., 1812, p. 370. *Wollaston Collection, Cavendish Laboratory, Cambridge.*

816k. Wollaston's Camera Lucida adapted to Telescope. *Wollaston Collection, Cavendish Laboratory, Cambridge.*

857a. Automatic Motion for the Spectroscope. *Walter Baily, Leeds.*

The apparatus consists of an axle and four parallel discs, the outer pair being fixed, and the inner pair rigidly connected together, and capable of turning on the axle. Between the inner discs are four arms, which also turn on the axle.

Taking the centre of the axle as origin, each disc has 4 slits, the equation to their middle lines being $r = \mathrm{F}(\theta)$, $r = \mathrm{F}\left(\frac{\theta}{2}\right)$, $r = \mathrm{F}\left(\frac{\theta}{3}\right)$, $r = \mathrm{F}\left(\frac{\theta}{4}\right)$. The discs in each pair are placed with their slits parallel, but the inner discs are turned over. The arms have straight slits radiating from the axle. A pin is passed through the first slits of the outer discs, the 4th of the inner discs, and the slit in one of the arms. The remaining arms are connected with the discs by three other pins inserted in a similar manner. The first and last prisms are fixed on the initial lines of the outer and inner pair of discs respectively, and the four other prisms are carried by the arms. Motion is given by moving the inner discs. The angles at which the slits cross are constant and differ least from right angles if $\mathrm{F}(\theta) = ae^{\theta\sqrt{5}}$, which is the form adopted in the model.

877a. Handy Polariscope with Nicol prisms to show rings in biaxial crystals. *W. Previte Orton.*

This instrument was designed by the exhibitor and made for him by Pastorelli. Its object is to utilise the Nicols of a small microscope so as to show the effect of polarised light in a biaxial crystal ; and further, to do this in a handy and manageable and inexpensive form.

[illegible]. 2. [illegible]meter. Before the eye-piece of the glass, [illegible] double refracting prism is made to turn until a wire, moving p[illegible] pendicularly to the principal section of the prism, gets to p[illegible] through the two intersecting points of the two reflections of [illegible] ellipse. An index shows at the moment the position of [illegible] prism.

[illegible]. New Optometer, with double-refracting lens of [illegible] spar, giving double readings, and greater precision in determin[illegible] the distance of sight. *Professor Carl Wenzel Zenger, Prag[illegible]*

Pyrites, burnt ore, burnt ore ground and mixed with salt, burnt ore [illegible] furnacing, burnt ore after lixiviation, "purple ore," brick of purple ore, [illegible] copper liquor, waste copper liquor, copper precipitate, iodide of zinc, iodi[illegible] silver, silver precipitate. (Widnes Metal Co.)

Salt, saltcake, Hargreave's process. (Mr. Sullivan & Co.)

Nitre, [illegible] or nitre cake, vitriol. (Messrs. Muspratt & Sons.)

Salt, saltcake. (Messrs. Sullivan & Co.)

Hydrochloric acid. (Messrs. Mathieson & Co.)

Limestone, slack, black ash, vat liquor. (Messrs. Sullivan & Co.)

Waste before oxidation, waste after oxidation, sulphur liquor, precipit[illegible] sulphur, melted sulphur, roll and bulk. (Messrs. Hutchinson & Co.)

[illegible] & Co.)

[illegible] (Muspratt & Sons.)

[illegible] (Gaskell, Deacon & Co.)

[illegible] (Hutchinson & Co.)

[illegible] red liquor, cream caust[illegible] [illegible] soda, 70 per cent. [illegible]

[illegible] mud before and [illegible] bleaching powder. (Math[illegible] & Co.)

[illegible] (Gaskell, Deacon & Co.)

[illegible] chlorate of lime first crys[illegible] [illegible] crystals, chlorate of potash, ground chlorat[illegible] [illegible] (Muspratt & Sons.)

[illegible] silicate of potash solution alk[illegible] [illegible] silicate of potash. (Gos[illegible] & Co.)

940. Photographic Prints, in ink.

Mr. Thiel Aîné, P[illegible]

[illegible]

[illegible] water-colour painting. A cow, after Troyo[illegible]

[illegible] drawing. [illegible] the Marquis [illegible]

[illegible] drawing. An old courtyard at Colombes.

[illegible] The Resurrection, after Lazerges.

[illegible] drawing. Borders of the Rhine at Mulh[illegible] [illegible] Nisslerhausen.

[illegible] drawing. Ruins of a temple, after Lalann[illegible]

[illegible] painting. Presenting the Bride, after de Bou[illegible]

CLASS THE 2ND.

8. Reproduction of chalk drawing—In the park at Plombières, Vosges, after Allongé. (Salvon, 1875.)
9. „ of chalk drawing—Rocks and lake, after Appian.
10. „ from nature—Church of St. Augustin, Paris.
11. „ „ —Opera-house, Paris.
12. „ „ —Notre Dame, Paris.
13. „ of chalk drawing—Borders of the Lake of Arandon, after Appian.
14. „ of chalk drawing—Borders of a pond, after Allongé.

CLASS THE 3RD.

15. Reproduction of terra-cotta—Marguerite with the jewels, after Carrier-Bellenze.
16. „ of oil painting—The imprisoned loves, after Chaplin.
17. „ from nature—Study of foreground, stereotyped on paper of Mr. H. Le Secq.
18 „ from nature—Cathedral of Rheims, stereotyped on paper of Mr. H. Le Secq.
19. „ of chalk drawing—The Bois de Boulogne, after Lalanne.
20. „ from nature—Cathedral of Rheims, stereotyped on paper of Mr. Le Secq.
21. „ from nature—Study of foreground, stereotyped on paper of Mr. Le Secq.
22. „ of oil painting—The death of Asala.
23. „ of drawing—Head of Christ, after Lazergues.

CLASS THE 4TH.

24. Reproduction of oil painting—Diana's toilet, after Devedeux. (Imitation of photography with salts of silver.)
25. „ from nature—A hawk; still life. (Imitation of photography with salts of silver.)
26. „ from nature—Sèvres vases. (Imitation of photography with salts of silver.)
27. „ from nature—Naumachy in the Park Monceaux. (Imitation of photography with salts of silver.)
28. „ of chalk drawing—The borders of the Yères, after Allongé.
29. „ from nature—The bridge of Solférino, Paris. (Imitation of photography with salts of silver.)
30. „ from nature—Sèvres vases. (Imitation of photography with salts of silver.)
31. „ of a print—Musings, after de Moussy.
32. „ of terra-cotta—The Mountebank's, after Deca.

983c. Magic Mirror. *Robert von Tarnow.*

This mirror is a curiosity, and consists of a brass concave disc with finely polished surface. At the reverse rough side there are several Arabic characters in relief. By exposing the polished surface to the rays of the sun in such a way that they reflect them on the wall, the Arabic figures of the reverse side of the disc become plainly visible in the reflected light on the wall.

996a. Drawings of Bull's Patent Semi-continuous Brick Kilns. *Hermann Wedekind.*

[illegible]

[illegible] First [illegible]

[illegible]

[illegible] Electric [illegible]

[illegible]

[illegible] of the Royal [illegible]

[illegible] Electric [illegible]

[illegible]

3a. Dynamo-Electric Light Apparatus. This ma-
;ives a light of 4,000 normal candles with 850 revolutions
ırmature per minute, with an expenditure of work equal to
·power. *Siemens and Halske, Berlin.*

3b. Dynamo-Electric Light Machine producing a
qual to 1,000–1,300 normal candles with about 1,100 revo-
of the induction cylinder per minute and an expenditure of
H.P. The machine is 640 millimetres in length, 540 milli-
width, and 225 millimetres height.

Siemens and Halske, Berlin.

3c. Magneto-Electric Machine to give a constant
. The apparatus has 50 steel magnets, and the current
d is equal to that from 8–10 Bunsen's elements. The
e is rotated by hand. *Siemens and Halske, Berlin.*

). Electric Lamps, 1 small and 1 large. These lamps
)matic in their motion; in them the carbon points are caused
)ach or recede from each other.

Siemens and Halske, Berlin.

l. Sine-Tangent Galvanometer, for use at will either
e or tangent galvanometer. *Siemens and Halske, Berlin.*

5. Aperiodic Galvanometer, with telescope and scale.

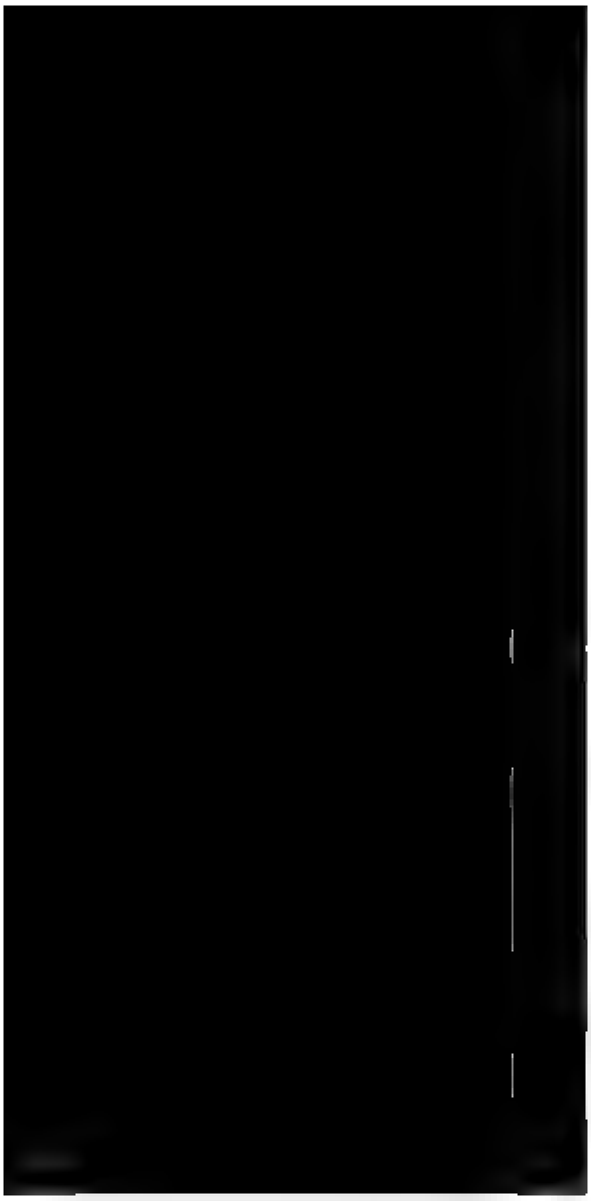
Siemens and Halske, Berlin.

edle of this galvanometer is suspended in a copper ball, which acts
ıper, preventing vibration in any new position given to the needle.
lle itself is in the shape of a thimble cut away longitudinally on
sides, and by this arrangement the magnetic intensity is considerably
l, and the inertia of the magnet reduced. Du Bois Raymond has
ıat the "damping" of an astatic needle can be carried so far that the
oes not vibrate, but directly takes up its position of deflection, and he
ied these "aperiodically vibrating needles." Dr. Werner Siemens
ined the same end with simple non-astatic magnets, by means of
orms of the vibrating magnets, and of the damping copper mass.
ating magnet consists of a steel thimble, from which two opposite
cut away parallel to the axis. This horseshoe magnet vibrates in a
al space in a copper ball, which forms the centre of the wire coils.

7a. Revolving Coil used in the determination of the
ish Association Unit of Electrical Resistance,"
. (The property of the British Association.)

Prof. Clerk Maxwell.

oil forms a closed conducting circuit. As the coil revolves about a
axis, the horizontal component of the earth's magnetic intensity
an alternating current in the coil. A very small magnet is sus-
ıt the centre of the coil, and is deflected from the magnetic meridian
ırrent in the coil. When the coil revolves rapidly, the alternations
ırrent do not produce any sensible vibration of the magnet, and the



[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

netic Telegraph Apparatus.

Siemens and Halske, Berlin.

may be any dial instruments in which the currents are nets. The receiving instrument prints upon a paper riband e wheel, at the same time indicating on a dial the letters heel is of vulcanized caoutchouc instead of metal.

Automatic Cylinder Transmitters and print- working **Duplex,** *i.e.*, so arranged that messages tted from both stations simultaneously.

Siemens and Halske, Berlin.

is an automatic finger key instrument, in which the letters are formed in Morse code upon a cylinder of wires, these d forward by levers connected with the finger keys, so that keys corresponding to the letter to be sent, the complete rmed in the wires, which afterwards are brought by revolu- der into contact with levers connected to the battery and

omatic Type-printer, including transmitter, re- ient, and relays. *Siemens and Halske, Berlin.*

is an automatic finger key instrument, in which the currents are controlled by a cylinder of wires, these wires being y levers connected with the finger keys, so that by depressing ding to the letter to be sent the necessary combination is es, which afterwards are brought by revolution of the cylinder levers connected to the battery and line, and by this means urrents requisite to bring the type wheel of the receiving desired letter are sent into the line. The relay consists of of aluminium bobbins wound with silk covered wire, which r expelled from an intense magnetic field, according to the rrent received in the coils from the transmitting instrument, ng contact to be made by their movement. The receiving double type wheel worked by an escapement, which is lectro-magnets brought into play by the currents received

rge and Discharge Keys (new form).

Warden, Muirhead, and Clark.

omatic Printing Telegraph, constructed by Christiania.

C. H. G. Olsen, Optician, Christiania.

onsists of two principal parts.

apparatus, on which the messages are prepared thus:— of the keys of a keyboard in the apparatus, holes will be r ribbon, corresponding to letters and signs marked on the ibbon is rolled up and applied in—

apparatus, where it is run over a metallic roller. When- ars, a steel pin will make contact with the roller and e line. The current will liberate the armature of a magnet, with engraved signs and letters will revolve, and another ied under this wheel, is lifted into contact with it. If

wheel has its right position to the writing on the perforated paper, the le[illegible] desired will appear printed on the paper. (2 photographs, 7 drawings, [illegible] a more detailed description follow.)

1709c. Contact Breaker, with two discs, which can [illegible] displaced, and sliding springs on glass inlets.

Prof. Dr. Dove, Berl[illegible]

(See Transactions of the Royal Academy of Sciences at Berlin, 1[illegible] p. 296.)

1722a. Davis' Quadrant or Back Staff. The first nat[illegible] instrument for taking altitudes of the sun with reference to [illegible] visible horizon. This instrument was the prelude to Had[illegible] quadrant and the reflecting sextants and circles of the present [illegible] The property of the Royal Astronomical Society, presented [illegible] R. J. Lecky.

Robert J. Lecky, F.R[illegible]

1722b. Double Reflecting Circle, by Capt. Owen, [illegible] The property of the Royal Astronomical Society.

Robert J. Lecky, F.R[illegible]

This invention of the late Capt. Owen, R.E., is peculiarly valuable [illegible] readiness with which two observations or "sights" can be taken wi[illegible] without removing the instrument from the eye, e.g., in a lunar obser[illegible] at sea [illegible] of the star and the lunar distance may be taken with [illegible] as well as [illegible] observations.

The two [illegible] each six inches diameter are divided on silver and r[illegible] [illegible] to 20 seconds of arc, and the glasses being [illegible] between [illegible] are well defended from accident at sea. It has [illegible] of much ingenuity.

1754a. Ancient Astrolabe, supposed to have belong[illegible] the Spanish Armada.

Robert J. Lecky, F.R[illegible]

[illegible] instrument was found under a rock in the island of Valencia, I[illegible] 1845 [illegible] the place where three vessels of the Spanish [illegible] were wrecked, and from the style of its finish and workmanship is su[illegible] [illegible] of them.

1757a. Large Bronze Astrolabe, which belonged to[illegible] Philip II. of Spain.

Archæological Museum, M[illegible]

Near the base are the following inscriptions, giving the date a[illegible] [illegible]

[illegible] Arsenius Frisi Nepos Lonanu fecit [illegible] The diameter of this instrument is 0·59m.

1757b. Bronze Astrolabe, made in the 16th c[illegible] Diameter, 0·[illegible]

Archæological Museum, M[illegible]

1757c. Arabian Astrolabe. Made at Toledo. A.D[illegible] Diameter, 0·[illegible]

Archæological Museum, M[illegible]

[illegible] at Toledo, as stated in the Arabic inscription eng[illegible] [illegible] month of Shawal [illegible] of the works superinte[illegible] the Hegira [illegible] Asschli, at Toledo. In the 459th

This year began on the 21st of November of 1066, and ended on the 10th of the same month of 1067. The famous astronomer Ararquiel, called by Guillermo Anglicus, *Pater Isaac*, lived at Toledo at this period, and this instrument may have been made under his directions. It contains five plates giving the latitudes. The translations of the inscriptions will be found in the interesting study on astrolabes, published by Dr. Eduardo Saavedra in the "Museo Español de Antiguedades," V. VI., pp. 402-414. It is worthy of notice that European numbers are to be met with on several of the plates, which would make it appear probable that the instrument had been used by some Christian astronomer not knowing Arabic. The number of towns mentioned, ranging from Persia to the coast of Movono, and several Spanish towns, is much more extensive than on similar instruments of the kind.

1757d. Bronze Arabian Astrolabe. Diameter, $0 \cdot 21^{m}$.
Archæological Museum, Madrid.

Astrolabe without name of maker, date, or locality; but it may be surmised from the Arabic inscriptions on it that this instrument was made at Morocco, in 1774.

1757e. Memoir written by Don Eduardo Saavedra upon several Arabic astrolabes existing in Spain, published in the "Museo Español de Antiguedades."
Archæological Museum, Madrid.

1757f. Bronze Astrolabe, without date or maker's name, and was probably made in Italy in the 16th century.
Ministry of Marine, Madrid.

1762a. Description of Revolving Puddling Furnace.
Thomas Russell Crampton.

The peculiarity of this revolving puddling furnace is that one chamber forms the gas producing, combustion, and working chamber, no separate fire-place, fire-bricks, or fire-bars being employed. The heat being produced without smoke by the automatic injection of powdered fuel and air into the chamber. The whole furnace is protected by water circulating between a double casing.

Puddle balls of wrought iron up to 30 cwt. can be produced in one mass without fatigue to the men; the puddling being effected by revolving the furnace mechanically.

1775a. Arabic Quadrant in bronze, made by Ahmed Ibn Abd el Rahman. *Archæological Museum, Madrid.*

Its radius is $0 \cdot 21^{m}$. It has an inscription in Ensic letters of the latter end of the middle ages giving the name of the maker.

1849a. Plaster Cast of a Sun-dial. The original is made of stone and is preserved at the Archæological Museum at Madrid.
Archæological Museum, Madrid.

This was found with a number of other objects at Yecla, in the province of Alicante, Spain. At the upper part there probably was formerly an iron limb to mark the hours, on the Roman system of dividing them in couples. In order to use it the dial was placed in the shade, facing the north. A small

2149a. Drawing of Steam Vessel, by the exhibitor.
The late Baron Séguier, Membre de l'Institut.

2169a. Model of Wrought-iron Ship's Block, by the exhibitor. *The late Baron Séguier, Membre de l'Institut.*

EXHIBITED BY THE SOUTH KENSINGTON MUSEUM.

2153d. Model of H.M. Steam Troopship "Orontes," on a $\frac{1}{4}$ scale, showing the arrangement of three canting bridges for lifeboats, with lifeboats built on Lamb and White's principle. Also 10 of Captain J. W. Hurst's patent life-rafts, lashed to ship's side.—J. White, Cowes.

2153e. Model of a Surf-boat, for service on West Coast of Africa. Built by Forrest and Son for the War Department, 1872–3. Scale 1 inch to 1 foot; length 25 ft., breadth 5 ft., depth 2 ft. 3 in.—Forrest and Son, Limehouse.

2153f. Model of Pleasure Boat. Built for Lord Castlerosse in 1861 for the use of Her Majesty during her visit to the Lakes of Killarney.—Searle and Sons, Lambeth.

2153g. Model of the Lifeboat and its Transporting Carriage, on about a $\frac{1}{10}$ scale; adopted by the Royal National Lifeboat Institution. Length 33 ft., breadth 8 ft., depth inside 3 ft. 4 in.

2153h. Pencil Drawing, by William Van der Velde, Amsterdam, 1663–1707. Hull of the ship of war "Sovereign of the Seas," 1687.—Mr. G. Smith.

2178ehh. Model, Martin's patent self-canting anchors; adopted by the British Government and fitted to H.M.'s ships "Devastation," "Thunderer," and others.—C. Martin, King William Street, E.C.

2178dn. Model of Small Steamer "Mab," the fastest on the Neva. Built in 1874, of brass, by George Baird, St. Petersburg.

Length - - - -	48 ft.
Breadth - - - -	6 ft. 6 in.
Depth at side - - -	3 „ 6 „
Draught - - - -	1 „ 7 „
„ over screw - - -	2 „ 9 „
Speed - - - -	19 miles.
Diameter of high pressure cylinder -	7 ins.
„ low „ -	11 „
Stroke - - - -	8 „
Working pressure - - -	120 lbs.
Revolutions per minute - -	600

George Baird, St. Petersburg.

2178ei. Whole Model of the German iron-clad ships of "**Kaiser**" and "**Deutschland.**" Built 1874 for the Imp German navy. 7,500 tons (displacement); 8,000 indicated ho power; engines by Penn and Sons, Greenwich.

Samuda Broth

2178ej. Whole Model of the "**Mahrousse,**" state pa steam yacht. Built for His Highness the Khedive of Egypt; burthen, 3,150; horse-power, 800 nominal. *Samuda Broth*

2178ek. Ship "Helen Rodger," China clipper, belon to Alexander Rodger, Esq., Glasgow; launched June 1858; le 153 ft., breadth 29 ft. 3 in., depth 19 ft. 6 in.; tonnage, 584 wooden ship. **Ship "Taeping,"** China clipper, belongi Alexander Rodger, Esq., Glasgow; launched December 1 length 185 ft., breadth 31 ft., depth 20 ft.; tonnage, 764 composite ship. **Ship "Ariel,"** China clipper, belon to Messrs. Shaw, Maxton, and Co., London; launched 1865; length 195 ft., breadth 33 ft. 9 in., depth 21 ft.; tonn $852\frac{21}{100}$; composite ship. **Ship "Lahloo,"** belonging to A ander Rodger, Esq., Glasgow; launched July 1867; length 19 breadth [illegible] ft., depth 2[illegible] ft.; tonnage, $799\frac{21}{100}$; composite sh

Robert Stuh and Co., Gree

2178el. Paddle Steamer "Hibernia," belonging t [illegible] Company, Glasgow; launched September 1842; le 21[illegible], breadth 35 ft. 10 in., depth 24 ft. 2 in.; ton [illegible] net 791[illegible]; wooden ship. **Screw Stea "Polynesian,"** belonging to the Montreal Ocean Comp [illegible] launched February 1872; length 400 ft., breadth 4[illegible] [illegible] tonnage, gross $4,282\frac{15}{100}$, net $2,023\frac{21}{100}$; [illegible]

Robert Stuh and Co., Gree

2178em. Model. Mid-ship section of a composite v [illegible] built and classed at Lloyd's for 11 years.

Nelson Dock Company, Lin

2178en. Model. Half mid-ship section of a composite v [illegible] built and classed at Lloyd's for 15 years.

Nelson Dock Company, Lin

2178eo. Model. No. 3. Half model of an old paddle ste

Nelson Dock Company, Lin

2178ep. Model. No. 4. After body and stern framin [illegible] East Indiaman *Nelson Dock Company, Lin*

2178eq. Half-block Model of a Yarmouth Her Boat, [illegible] "Lord [illegible]" and other Yarmouth fi [illegible]

H. Fell

2178er. The "Mary Taylor," New York pilot [illegible] by George Steers, an Englishman in New York, about

He afterwards built the celebrated "America" yacht. He told the exhibitor in New York, in September 1854, that he considered the "Mary Taylor" the faster vessel of the two, particularly in rough water. *Henry Liggins.*

EXHIBITED BY THE SOUTH KENSINGTON MUSEUM.

2178fa. Whole Model of the Cunard iron paddle steamer **"Scotia,"** built 1861. Constructed for the British and North American (Cunard) Royal Mail Steam Packet Company, by R. Napier & Sons, Glasgow. Length 366 ft., breadth 47 ft. 6 in.; tonnage, builder's measurement, 4,050; load displacement, 6,520 tons; horse-power, 1,000 nominal; diameter of cylinders, 100 in.; length of stroke, 12 ft.; diameter of paddle-wheels, 40 ft.; size of floats, 11 feet 6 in. by 2 ft.

2178fb. Whole Model of the Woodside ferry paddle steamboat **"Cheshire,"** employed between Birkenhead and Liverpool. Licensed to carry 1,620 passengers. Draught of water 6 ft.—Designed by Mr. George Harrison, M.I.C.E.

2178fc. Whole Model of the screw steamship **"Faraday."** Built by Mitchell & Co., Newcastle, in 10 months, 1874, for Messrs. Siemens Brothers, for employment in carrying and laying electric telegraph cables for ocean telegraph lines.—Dr. C. W. Siemens, Queen Anne's Gate.

2178fd. Half Model of the iron sailing ship **"Victory."** Built 1863. Tons 1,198.—Designed and built by Laurence Hill & Co., Glasgow.

2178fe. Half Block Model of the Royal Mail screw steamship **"Boyne."** Built 1871. Length (keel) 358 ft. 6 in., breadth 40 ft. 5 in., depth 34 ft. 6 in.; tons o.m. 2,882.—W. Denny and Brothers, Dumbarton.

2178ff. Half Model of paddle steamer **"Glengyle."** Constructed for the navigation of the river Yangtzee. Tons 2,040; horse-power, 400 nominal.—W. Denny and Brothers, Dumbarton, N.B.

2178fg. Half Model of a corvette of the **"Alabama"** class. Proposed by Mr. George Turner, late master shipwright, Woolwich Dockyard.—Mr. George Turner.

2178fh. Photograph of H.M. Indian Relief Troopship "Malabar." Built and engined, 1867, by R. Napier and Sons. Length 360 ft., breadth 49 ft., depth, 22 ft. 4 in.; tonnage, 4,173; horse-power, 700. *R. Napier and Sons, Glasgow.*

[illegible]. Whole Model of H.M. Indian relief steam [illegible] "[illegible]." Built 1866, by Palmer's Shipbuilding C[illegible] [illegible] breadth 48 ft. 9 in., depth 42 ft.; ton[illegible] [illegible] horse-power, 700 nominal; speed, 14½ knots p[illegible] [illegible] scale.—Palmer's Shipbuilding Company, L[illegible] Newcastle-on-Tyne.

[illegible]. Whole Model of the Mail Screw Steamer "[illegible]," [illegible] and New York line. Built 187[illegible] Palmer's Shipbuilding Company, Limited. Length [illegible] [illegible] depth 27¼ ft.; tonnage gross, 4,320 hor[illegible] [illegible] speed, 15½ knots per hour; scale, [illegible]th ful[illegible] The Palmer Shipbuilding Company, Limited, Newcastle[illegible]

[illegible]. Model of the **After Body,** showing [illegible] [illegible] of the Screw Steamer "**Novelty.**" Built [illegible] Mr H. [illegible].

[illegible] was the first fitted with direct-acting engines [illegible] of shipping and unshipping the pr[illegible]

[illegible]. Whole Model, [illegible] of a **Thames Sailing** [illegible] [illegible] breadth 16 ft., depth 6 ft. [illegible]

[illegible]. Whole Model of the Australian life-boat "[illegible]" [illegible] designed by Mr W. [illegible] 1867. Length 43 [illegible] 4 [illegible] scale, ¾ inch [illegible] presented to His Royal Highness the [illegible] [illegible] Marine Board of South Australia [illegible]

[illegible]. Sectional Drawings of the paddle st[illegible] "**London Engineer**" [illegible] Maudslay, Sons and Fie[illegible]

Maudslay, Sons, a[illegible]

[illegible]. Drawing showing the first iron vessels [illegible] the River Gang[illegible] [illegible] date 183[illegible]

Maudslay, Sons, [illegible]

[illegible]. Drawing showing [illegible] set of same [illegible]

Maudslay, Sons, a[illegible]

[illegible]. Photograph of White Star mail steamers [illegible] "**Germanic.**" Built by Harland a[illegible] [illegible] Maudslay, Sons and Field. Length [illegible] horse-power nominal.

Maudslay, Sons, a[illegible]

2178fq. Model of the inverted cylinder compound engines, P. and O. Co.'s ship "**Pera**" on the compound system of 2,000 horse-power, 1372. *J. and G. Rennie.*

2178fr. Model of the first screw-steamer in the British Navy, "**Mermaid**" afterwards named the "**Dwarf.**" Built in 1840. Purchased from J. and G. Rennie by the British Admiralty, according to Sir George Cockburn's advice, on the condition she should steam 12 miles per hour (7th March 1842) tried 15th May 1843. Mean speed of 6 runs—12·142 miles. *J. and G. Rennie.*

2178fs. Model of H.M. Gun Boats "Arrow" and "Bonetta." Built by J. and G. Rennie, 1871. Length 85 ft., breadth 26 ft., depth 8 ft. 10 in.; tons, 244. To carry one 18 ton gun. *J. and G. Rennie.*

2178ft. Model of the Iron Paddle-wheel Steamer "Queen." Built and fitted with engines by J. and G. Rennie, 1842. Length 160 ft., breadth 17 ft., depth 9 ft. Speed between 17 and 18 miles per hour, which exceeded that of any vessel on the Thames. *J. and G. Rennie.*

2178fu. Model of Indian Famine Relief Steamers. Built by J. and G. Rennie, 1874. Date of order, 24th February. Date of launch, 30th March. Tried under steam, 4th April. Length 90 ft., beam 14 ft., depth 5 ft. 6 in.; indicated horse-power, 100. Built complete with engines in 35 working days. *J. and G. Rennie.*

2178fw. Model of Twin-Screw Gun Boats. Built for the East Indian Government by J. and G. Rennie, 1857. Length, 70 ft., breadth 11 ft., draught 2 ft. 6 in.; nominal horse-power, 20; indicated horse-power, 76; speed, 9¼ miles. Armament, one long brass 12-pr., 18 cwt. *J. and G. Rennie.*

2178fx. Model of Brazilian Twin-Screw Ironclad Gun Boats "Colombo" and "Cabral." Built by J. and G. Rennie, 1866. Length 160 ft., breadth 34 ft., depth 17 ft.; tons, 858 B.M.; nominal horse-power, 240; speed, 10 knots. Armament, 4 68-prs. *J. and G. Rennie.*

2178fy. Model of Twin-Screw Gun Boats. Built for the Spanish Government by J. and G. Rennie, 1859. Length 90 ft., breadth 14 ft., draught 2 ft. 6 in.; horse-power, 30. *J. and G. Rennie.*

2178ga. Model of Mr. Joseph Maudslay's **Original Oscillating Cylinder Engines.** Date 1827. (The arrangement for working the air pump is not that originally fitted.) *Maudslay, Sons, and Field.*

[illegible]. Model of Patent Annular Cylinder Eng[illegible] [illegible] Sons, and Field, as fitted in first improved C[illegible] [illegible] "Princess Alice" (Dover to Calais), 1843.

Maudslay, Sons, and [illegible]

[illegible]. Model of Double Piston-rod Steeple Eng[illegible] [illegible] Hon. East India Company's vessels on the [illegible] [illegible]

Maudslay, Sons, and [illegible]

[illegible]. Sectional Model of Side by Side Cyl[illegible] [illegible] Compound Engines. John Milner, C.E., [illegible]

Maudslay, Sons, and [illegible]

[illegible]. Two Drawings of the Four Cylinder In[illegible] Compound Engines, fitted by Maudslay, Sons, and Field, [illegible] the White Star line ("City of Richmond [illegible]

Maudslay, Sons, and [illegible]

[illegible]. Original Oscillating Paddle Engines, [illegible]

Maudslay, Sons, and [illegible]

[illegible]. Bobbin Winding Machine, by the la[illegible]

Maudslay, Sons, and [illegible]

[illegible]. Drawing. First [illegible] screw engines [illegible] Field, in 1846 (H.M.S. "Ajax [illegible] nominal collective).

Maudslay, Sons, and [illegible]

[illegible]. Drawing, showing arrangement of machine[illegible]

Maudslay, Sons, and [illegible]

[illegible]. Drawing, showing **Engines** of H.M.S. "[illegible]" [illegible] "Terrible," 800 [illegible] engines.

Maudslay, Sons, and [illegible]

[illegible]. Drawing of Beam Engines of 220 horse [illegible] **"Rhadamanthus," "Phoe[illegible]," "Medea,"** [illegible] 1832.

Maudslay, Sons, and [illegible]

[illegible]. Drawing of a Portable Engine, 1828.

Maudslay, Sons, and [illegible]

[illegible]. Drawing [illegible] oscillating **E[illegible]** [illegible] "Sylph" [illegible] 1836.

Maudslay, Sons, and [illegible]

[illegible]. Drawing of Machinery for Boring C[illegible]

Maudslay, Sons, and [illegible]

2178go. Drawing of Machinery for Boring Cannon, for Rio Janeiro, 1813. *Maudslay, Sons, and Field.*

2178gp. Model of the **Engines** of H.M. ships "**Boadicea**" and "**Bacchante,**" on the compound system, of 5,250 horse-power indicated, 1875 and 1876. *J. and G. Rennie.*

2178gq. Model of Horizontal Marine Engines, with injection condensers. Made by J. and G. Rennie, 1860.
J. and G. Rennie.

2178gr. Model of Reversed Horizontal Marine Screw Engines. Built 1860. *J. and G. Rennie.*

2178gs. Drawing, design for **60 horse-power Low Pressure Condensing Disc Engines for Screw Steamship.**

The drawing shows front, side, and back elevation and plan.
Section of H.M.S. "Cruiser," fitted with the disc engines, 1853.
J. and G. Rennie.

2178gt. Album containing **Drawings of Marine Steam Engines,** designed by R. Napier and Sons from 1838 to 1840, for steamships "British Queen," and vessels of the Cunard line, Transatlantic service. *R. Napier and Sons, Glasgow.*

2178gu. Compound Surface-Condensing Marine Engines. *T. Richardson and Sons, Hartlepool.*

Three drawings of marine engines of the most modern construction.

One drawing represents engines of the largest class fitted with steam reversing gear.

Another drawing represents engines of a more moderate size, and gives the names of the vessels into which they have been fitted.

A third drawing represents marine engines of the smaller class.

The three drawings all represent compound surface-condensing engines.

2180e. Memoir, written by Don Fernandez Duro, upon the models of metal plated ships made in the last century, preserved at the Ministry of Marine at Madrid. With plates.
Archæological Museum, Madrid.

2181a. Model of the Old Lighthouse on the Smalls Rocks, about 17 miles off the coast of Pembrokeshire. Erected 1776; replaced in 1861 by a stone lighthouse. The model is made out of one of the oak pillars of the original lighthouse. —Executors of the late Captain Pickering Clarke, R.N.
South Kensington Museum.

2181b. Model of the Lighthouse on the Needles Rocks, Isle of Wight. Built 1857–1858. Light shown 1 January 1859.—Trinity House, London. *South Kensington Museum.*

2181c. Model of the Gunfleet Lighthouse. Iron. Built on Mitchell's patent screw piles, of which a model is also shown. The piles screw 40 ft. into the sand, and have screws 4 ft. in diameter. James Walker, engineer.—The Trinity House.
South Kensington Museum.

2181d. Series of Models, illustrating mark buoys, used by the Trinity House Corporation round the British coast.—The Trinity House. *South Kensington Museum.*

2181e. Harbour Light. Chance's patent dioptric lens of the fourth order, for fixed light.—Chance Brothers and Company, Glass Works, Birmingham. *South Kensington Museum.*

2209a. Ship's Light, arranged to show a port, starboard, or anchor light.—J. S. Starnes, Broad Street, Radcliff, E.
South Kensington Museum.

2209b. Ship's Lights, port, starboard, and mast head light. —Stevens & Sons, Southwark Bridge Road.
South Kensington Museum.

2210d. Photographs of the first engine employed on a public railway, of the first and of the most modern railway coaches, and of the first two railway bills. *Alfred Marshall.*

2212f. Model of Railway with central rail, 1[illegible]3.
Late Baron Séguier, Membre de l'Institut.

2212g. Model of Central Rail Locomotive with its rail (1842). *Late Baron Séguier, Membre de l'Institut.*

2212h. Model of Central Rail Locomotive, by Baron Séguier and Dumery, with part of the road, 1862.
Late Baron Séguier, Membre de l'Institut.

2212k. Fog Signal. *Edward Alfred Cowper.*

This simple little instrument illustrates the application of the science of acoustics to a very useful object, namely the communication of information from a person on a railway to the driver of a passing train, in a dense fog or on a dark night. It is the only instrument that accomplishes the object, and has been the means of saving many thousands of lives. Invented by the exhibitor in 1841.

Its principle consists in producing a very different sound from any that is constantly recurring in a railway train, and a sudden explosion or detonation is found to be the best for the purpose; it is caused by the explosion of a small quantity of gunpowder in a small tin box, by the firing of a match inside which is crushed by the wheel of the passing train.

2216d. Drawing of Steam Carriage, by the late Baron Séguier, with "sun and planet wheel motion." 1846.
Late Baron Séguier, Membre de l'Institut.

Relics.

2397. Frame containing proofs in **John Dalton's** handwriting of part of the "New System of Chemistry." Vol. II. Part I. Pages 347, 349, and 352. *Professor Roscoe, F.R.S.*

2409. Apparatus by which the body in the atmosphere which acts upon Schönbein's test-papers was first certainly proved to be identical with ozone. *Dr. Andrews, F.R.S.*

Atmospheric air, in fine weather and acting freely upon the test-papers, was drawn steadily through a glass globe, capable of being heated to 300° c., when all chemical reactions disappeared, which could only occur in the case of ozone.

2456b. Apparatus for simultaneous production of hydrogen, carbonic acid, and sulphuretted hydrogen.

P. Waage, Professor of Chemistry and Director of the Chemical Laboratory at the Royal University of Christiania, Norway.

The apparatus consists of a reservoir for hydrochloric acid of 10–15 per cent. strength. At the bottom of this reservoir are three apertures through which it is connected in the usual manner by glass tubes and stopcocks with three cylindrical jars, one filled with zinc, the second with marble, and the third with sulphide of iron. Beneath each of these, and communicating with the sewers, is another reservoir into which the solutions of chlorides are gathered. The three gases generated are conducted through wash bottles furnished with stopcocks of glass; when these are turned off the several gases and the solutions of chlorides will pass through the lower reservoirs into the sewers.

The apparatus once fitted up is always ready for use, and all superfluous gas is completely led away without producing any smell in the room where the apparatus is fixed.

2476a. Chrysoidine, a new basic orange dye for silk, wool, cotton, leather, &c. Manufactured by the exhibitors.

Williams, Thomas, and Dower.

Chrysoidine is, according to quality, the sulphate or hydrochlorate of a new bi-acid base, belonging to the benzene series. It is a valuable orange-yellow, and owing to the readiness with which it crystallizes, can be obtained in a state of perfect purity. Except phosphine, it is the only basic yellow dye known, and as it is the result of a direct process (not a secondary product) it can be obtained at a much lower price than phosphine, which it equals, and in some of its applications surpasses in strength and beauty of shade. It dyes in neutral or slightly basic baths, and has a great affinity for silk, wool, and even for unmordanted cotton. Mordanted cotton is dyed a yellow or orange shade according to the mordant employed. It combines readily with magenta and other red colours, giving rise to very clear and beautiful scarlets. The chrysoidine was discovered quite recently in our laboratory by Dr. Otto N. Witt.

2740a. Rudorff's Apparatus for determining the carbonic acid in illuminating gas.

W. J. Rohrbeck and F. Luhme and Co., Berlin, Dr. Herm. Rohrbeck.

onsecutive experiments made with illuminating gas, resulted in con- ›n of potash-lye :—

12·0 cc. = 1·36 per cent.
12·1 cc. = 1·37 „ „
11·8 cc. = 1·34 „ „

ıpparatus, of course, is only intended for ascertaining small quantities ›nic acid, such as is the case with illuminating gas. The other com- parts of gas are of no perceptible influence on this method.
analyses mentioned prove this sufficiently in order to secure for a a certain adoption in practice, which recommends itself just as well rustworthy results, as by easy and speedy execution.

8a. Special set of Observatory Standard Meteoro- ıl Instruments. Negretti and Zambra's special selection dard meteorological instruments for a first class observatory , consisting of:—Standard barometer, maximum thermo- Rutherford's minimum thermometer, mercurial minimum ›meter, hygrometer, wet and dry bulb, solar radiation ther- er, terrestrial radiation thermometer, Robinson's anemometer, ıuge (Glaisher's pattern). *Negretti and Zambra.*

6a. Standard Barometer with Electrical Adjust- *Negretti and Zambra.*

ıs a tube dipping into a glass cistern of mercury, fitted with a vertical ent screw. Through the top of the tube a platina wire is passed and ally sealed. The cistern has a metallic connexion, so that by means r wires (in the frame) a galvanic circuit is established; another con- also exists by a metallic point dipping into the cistern. The circuit, , can be cut off from this by means of a switch placed about midway frame. On one side of the tube is placed a scale of inches, with a vernier, divided into 100 parts, connected with the dipping point and at right angles with the scale.

6b. Negretti and Zambra's Standard Barometer, ıcted on Fortin's principle, proved to be the most reliable ement yet introduced. The level of the mercury in the being adjusted previous to each observation to a fixed ivory ›int, loss of mercury from leakage or oxidation is of little or ›ortance, and does not affect the accuracy of the readings. ıbes are of varying internal diameter, and are filled with ıercury, very carefully boiled in the tube to perfectly expel or moisture. *Negretti and Zambra.*

6c. The Gun Marine Barometer, constructed by ti and Zambra for special use in Her Majesty's navy, and ıe adopted Admiralty pattern. It differs from barometers o made by having its tube packed with vulcanised india- , which checks vibration from concussion, thereby doing vith the necessity of unshipping the barometer during gun

Admiral Fitzroy's report, 9th number of the Meteorological , issued by the Board of Trade. *Negretti and Zambra.*

[illegible]

very small instruments are found to act quite as correctly as the largest, and are much more convenient; they may be had with a range sufficient to measure heights of 20,000 feet, with a scale of elevation in feet, as well as of pressure in inches.

2822. Thermometers. The set of fourteen employed by the Exhibitor in experiments on the sensitiveness of thermometers. (Quarterly Journal Meteor. Soc., Vol. ii, p. 123.) *G. J. Symons.*

2827a. Plain Thermometer, Thermometer with Enamel Tube. *Negretti and Zambra.*

A plain and an enamel thermometer placed side by side, showing the immense advantage of the enamel over the plain. The extremely delicate investigations of medical and scientific men could not be carried on by the aid of such sensitive thermometers as are now manufactured had the process of enamelling not been introduced.

The enamel tube was *invented* by Negretti and Zambra.

2827b. Negretti and Zambra's Patent Mercurial Minimum Thermometer. *Negretti and Zambra.*

This thermometer has a plug of platina wire inserted in a small supplementary tube. When the thermometer is inclined, the mercury flows from the end of the supplementary tube until it reaches the platina plug, then by affinity of the mercury for the platina the column is maintained at the existing temperature; on a decrease of temperature the mercury recedes in the long or indicating tube, but on an increase of temperature it rises in the short tube, leaving the column of mercury in the thermometer indicating the minimum temperature.

2827c. Negretti and Zambra's Patent Recording Thermometer is upon the same principle as the deep-sea thermometer, but without the protected bulb. *Negretti and Zambra.*

In this case the instrument is turned over by a simple clock movement, which can be set to any hour it may be desirable; the thermometer is fixed on the clock, and when the hand arrives at the hour determined upon, and to which the clock is set, as in setting an alarum clock, a spring is released, and the thermometer turns over (as in the case of the patent deep sea thermometer), transferring the mercury from the thermometer to the auxiliary or recording tube.

2827d. Board of Trade Thermometer. Original instrument, as used formerly in Her Majesty's service. *Negretti and Zambra.*

The scale is brass, which, after constant use in salt water, soon becomes corroded and the figures obliterated.

2827e. Board of Trade Thermometers, with porcelain scales as patented by Negretti and Zambra, and now universally adopted. *Negretti and Zambra.*

[illegible]

[illegible] Thermometer.

[illegible]

[illegible] Thermometer.

[illegible]

[illegible]

[illegible]

[illegible]

2857b. Negretti and Zambra's Standard Dry and Wet Bulb Hygrometer or Psychrometer. *Negretti and Zambra.*

Two thermometers as nearly identical as possible are placed side by side, one marked DRY and the other WET. The bulb of the wet thermometer is covered with thin muslin, and has twisted round the neck conducting threads of cotton, passing into a vessel containing water placed on one side so that the water may not affect the reading of the dry bulb thermometer. The temperature of the air and of evaporations is given by the reading of the two thermometers, from which can be calculated the dew point.

3039a. Collection of Drawings in illustration of the progress in the construction of instruments employed in the science of geodesy, selected from various works published by the contributor. *Dr. Wilhelm Tinter, Professor of Practical Geometry at the I. R. Polytechnic Institute at Vienna.*

Illustrations of the Improvements in the construction of Surveyors' or Engineers' Tables.

1. Drawing and description of Practorius's table (1576–1616), after Daniel Schwenter (1623).
2. Drawing and description of Marinoni's table (1676–1755).
3. " " Kraft's table (1827), A., page 334.
4. " " Starke's table (1859 and 1873), A., page 336.

Illustrations of the Improvements in the construction of the appliances of sight required in the use of Surveyors' and Engineers' Tables.

5. Drawing of a simple alidade for taking the level towards one side, A., p. 340.
6. Drawing of an alidade for taking the level on both sides, A., p. 340.
7. Drawing of an alidade with mountain side-vanes, A., p. 340.
8. Simple perspective index (or ruler), after Sadtler (1816), A., p. 346.
9. Essentially improved construction of the perspective index, after Kraft (1854), A., p. 352.
10. Improved construction of the perspective index, after G. Starke (1867), A. and C., p. 356.
11. Improved construction of the perspective index, with Stampfer's surveying screw, after G. Starke (1832–1869), E., pages 53 and 55.
11*a*. Perspective index with turning water-poise (spirit level), after G. Starke (1874), M.

Illustrations of the Improvements in the Appliances for Reading the Graduated Divisions.

12. Nunnez, Pedro-Nonius (1497–1577), proposed the employment of auxiliary quadrants, variously divided (1542).
13. Hommel, John (1518–1562), proposed using transversals for dividing a circle.
14. Vernier, Pierre (1580-1637), proposed the employment of Vernier's (Nonius's) graduated scale (1631).
14A. Ramsden introduced the micrometer (or reading microscope, 1777). A., page 135, and D.

Theodolites and Universal Instruments.

15. Simple theodolite for land surveying, after G. Starke. A., page 259.
16. Repeating theodolite, after G. Starke. A., page 273.

[illegible] Astronomical universal instrument, after G. Starke. A., p[illegible]
[illegible] Astronomical universal instrument, after G. Starke. E., p[illegible]
[illegible] Astronomical universal instrument, with telescope in the [illegible] ...levelling purposes, after G. Starke. E., page 41.
[illegible] [illegible] instrument, after G. Starke. A., page 312.

Illustrations of the Improvements in the Construction of the Hyd[illegible] Wing.

[illegible] Older construction, after Woltmann (1790).
[illegible] Improved construction, after Sackur and Kraft.
[illegible] Improved construction, with differential wheels.
[illegible] Improved construction, after G. Starke. E., p. 73 (1870).
[illegible] Improved construction, after Amsler-Laffon (1870).
[illegible] Construction according to Amsler-Laffon with electr[illegible] ...[illegible] apparatus (1873). E., p. 73.

Illustrations of the Improvements in the Construction of Pla[illegible]

[illegible] Polar planimeter, after Amsler (1856).
[illegible] Momentum planimeter (Integrator), after Amsler (1856).
[illegible] E., page [illegible]
[illegible] Polar planimeter, after Miller and Starke (1856). A., 4 p[illegible]
[illegible] Polar planimeter, after Coradi and Ott (1874).
[illegible] Planimeter [illegible] Starke (1856, 1871). A., 4 part, [illegible]

[illegible] in the Construction of Level[illegible]

[illegible]

The foregoing illustrations are selected from the following publications by Dr. Tinter:—

A. Lectures on elementary geodesy (autobiographies).
A[1]. Lectures on the theory and practice of geodetical and astronomical instruments.
B. Mathematical, geodetical, and astronomical instruments (History of Trades and Manufactures and Inventions, 1873).
C. The perspective index, especially with regard to the construction given to this instrument by G. Starke.
D. The micrometer.
E. Universal Exhibition Report on astronomical and geodetical instruments.
F. Lectures on elementary geodesy, Part II.
G. G. Starke's universal levelling instrument, with telescope and Stampfer's surveying screw.
H. G. Starke's Universal levelling instrument with telescope.
I. G. Starke's Tachymeter.
K. Polymeter, by Jähns.
M. G. Starke's perspective index with turning water level.
A. Description of Praetorius's table, according to Schwenter.

3085a. Jacob's Staff, made to take astronomical observations, with double arcs; 17th century.
Ministry of Marine, Madrid.

3085b. Surveying Instruments of the 18th Century.
Ministry of Marine, Madrid.

3085c. Two Double Sextants, made in the last century by Davis. *Ministry of Marine, Madrid.*

3089a. Topographical Instrument, called **"Cleps,"** constructed by Messrs. Salmorraghi, Rizzi, and Co., Milan.
M. D'Abbordie, Member of the Institute, 120, *Rue du Bac, Paris.*

This altazimuth has three peculiarities:—
1st. The telescope is very powerful for its size.
2nd. Through the small transverse eye-piece the observer may read at the same time the horizontal and the vertical angle; the divided circles, completely covered, being lighted from above. To save time, there is neither microscope nor vernier, the angles being read in 10ths of divisions by three apparent wires, the means of which only are estimated.
3rd. The division is decimal; each hundredth of the dial is numbered, and divided into five parts.

This instrument, constructed for topography, is of small dimensions. In the larger model the division is carried to the thousandth of the dial. The error of collimation is ascertained by reversing the ring that supports the wires.

3105b. Twelve-inch Gun Metal Engineer's Level, with channelled bottom for setting flat work, shafting, &c. Very delicate. *Joseph Casartelli.*

)k. **Singing Flame Apparatus.**

)l. **Singing Flame Apparatus [octave higher].**

HEAT.

)m. **Differential Thermometer.**

)n. **Alcohol Thermometer.**

)o. **Mercury Thermometer.**

)p. **Bulb for determining Expansions.**

)q. **Apparatus for measuring Absolute Expansion iquid.**

)r. **Flask with Delivery Tube.**

)s. **Conductivity Cones.**

)t. **Hygrometer.**

)u. **Ventilation Apparatus.**

LIGHT.

)v. **Pin Hole Camera.**

)w. **Instrument for measuring Vertical Heights.**

)x. **Circle Dividing Board.**

)y. **Multiple Image Apparatus.**

)z. **Concave Mirror.**

)aa. **Convex Mirror.**

)ab. **Three Glass Bulbs and Beakers.**

)ac. **Glass Cell.**

)ad. **Bisulphide of Carbon Prism.**

)ae. **Spectroscope.**

)af. **Polariscope.**

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

OOobh. Electrophorus Cover.

OOobi. Reversible Net.

VOLTAIC ELECTRICITY.

Obi. Coil of Wire on Glass Tube.

Obk. Zinc and Copper Plates.

Obl. Astatic Galvanometer.

bm. Daniell's Cell.

bn. Wheatstone's Bridge.

bo. Rheocord and set of Resistance Coils.

p. Electric Bell.

q. Quadrant Electrometer.

. Thermopile.

. Water Decomposition Apparatus.

MAGNETISM.

Two-bar Magnets and Keepers.

Magnetized Needle.